U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF CHEMISTRY—BULLETIN No. 96.
H. W. WILEY, Chief.

INFLUENCE OF ENVIRONMENT ON THE COMPOSITION OF THE SUGAR BEET, 1904,

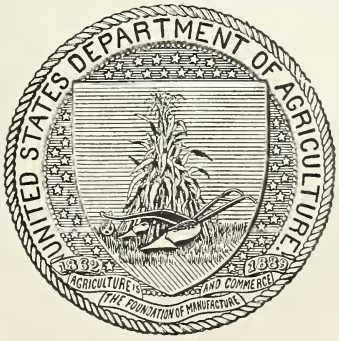
TOGETHER WITH

A SUMMARY OF THE FIVE-YEAR INVESTIGATION.

BY

HARVEY W. WILEY,
Chief of Bureau,

IN COLLABORATION WITH THE AGRICULTURAL EXPERIMENT STATIONS OF CALIFORNIA, COLORADO, INDIANA, IOWA, KENTUCKY, MICHIGAN, NEW YORK (GENEVA AND ITHACA), NORTH CAROLINA, UTAH, VIRGINIA, AND WISCONSIN.



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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Chemistry,
Washington, D. C., June 1, 1905.

Sir: I beg to submit for your approval manuscript and graphic charts embodying the results of the cooperative work conducted by this Bureau on the effect of environment on the composition of the sugar beet during 1904, together with a summary of the results obtained during the five years that this investigation has been making, the research being now completed. I recommend the publication of this report as Bulletin No. 96 of the Bureau of Chemistry.

The analytical work done in the Bureau on the beets was performed by Messrs. C. G. Church and Martin Boyle; that on the soils by Messrs. F. P. Veitch and T. C. Trescot. The cooperation of the various stations which took part in the experiment is deserving of recognition, but especially is the work of those stations appreciated which suffered no interruption throughout the five years, viz, Kentucky, Wisconsin, New York (Geneva and Ithaca), and Indiana, one year's data being missing in the case of the last-named station on account of failure of the crop. The Weather Bureau, the United States Coast and Geodetic Survey, and the Naval Observatory have also furnished certain data.

Respectfully,

H. W. Wiley, *Chief.*

Hon. James Wilson,
Secretary of Agriculture.

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INFLUENCE OF ENVIRONMENT ON THE COMPOSITION OF THE SUGAR BEET, 1904.

ORGANIZATION OF COOPERATIVE WORK.

In organizing the work for this year, the last of the present investigation, every effort was made to send explicit instructions and to insure the receipt of complete data. These instructions read as follows:

INSTRUCTIONS FOR SUGAR-BEET WORK, 1904.

For the purpose of the Bureau of Chemistry a square plat of one-eighth of an acre will be sufficient. It should be seeded heavily to insure a good stand and enough seed reserved for replanting if the first planting should not germinate.

PREPARATION AND SAMPLING OF SOIL.

The soil should have been plowed to the depth of 8 or 9 inches and subsoiled to at least 6 inches more, making a seed bed of at least 15 inches in depth. If the character of the soil warrants it, a deeper plowing, even to 10 or 11 inches, is advisable. The surface of the soil should be reduced to a fine tilth and well harrowed and stirred immediately before planting, to stop all growth of weeds that may have started.

Representative samples of the soil and of the subsoil from the plats on which these beets are grown are desired for chemical and physical analysis. After securing such a sample reduce it in size by quartering or otherwise to obtain final samples weighing not more than 4 pounds each. Place these in *paper bags* and then in the cloth bags sent herewith, using addressed marked tags, also forwarded. Please inclose a slip giving the kind of soil, date of sampling, etc., and send as complete a history of the plat as possible.

CULTURAL DATA.

The rows should be 18 inches apart and the seed planted at the rate of 25 pounds per acre. If the soil be moist, the seed should be covered to a depth of 0.5 to 1 inch. If the weather be dry, a slightly deeper planting is advisable.

As soon as the plants are vigorously growing they should be separated into clumps by a hoe 6 inches in width, leaving the length of 3 inches of beets in each bunch. When the beets have a vigorous growth and begin to form the fourth leaf, they should be thinned to about one plant in each 9 inches. If the soil be very fertile, the beets may be left closer together. Ordinary surface cultivation is all that is required, being careful not to cover up the beets at the first cultivation.

SAMPLING BEETS.

One month prior to the usual time of harvesting beets in your locality begin harvesting beets from the experimental plat. Harvest every beet in 50 feet of an inside row. Remove the leaves, clean the beets, and weigh them. Select 25 average beets, weigh them, and,

without topping, forward them to this Bureau by express, collect, inclosing description tag filled out. *Give all weights* and your estimate of the tonnage based upon beets from 50 feet of row. Repeat sampling once each week until frost prevents further operations or the beets begin to deteriorate.

FURTHER REPORTS.

More detailed reports will be gladly received for incorporation in the bulletin. If practicable, make check analyses from time to time for comparison with the analytical work done at this Bureau. While the Weather Bureau reports will be used for meteorological data, any additional observations, comments on special features of the season, etc., will be of service.

STATIONS COOPERATING IN 1904.

The following stations agreed to cooperate in the work: California, Colorado, Indiana, Kentucky, Michigan, New York (Geneva and Ithaca), North Carolina, Virginia, and Wisconsin. These experiments, together with those conducted at the Bureau of Chemistry on the Potomac flats, gave a total of eleven cooperating stations.

The seed furnished for this experiment by the botanist in charge of seed and plant introduction and distribution, Bureau of Plant Industry, was grown by E. H. Morrison, at Fairfield, Wash., from Kleinwanzlebener mother beets of exceptionally high sugar content and purity. The seed was of the 1904 crop and germinated 169.5 sprouts per 100 seed balls.

EXPERIMENTS CONDUCTED IN HUMID REGIONS.

POTOMAC FLATS, WASHINGTON, D. C.

As has been the practice at Washington, the beets were planted on four successive dates one week apart, and, the planting on May 20 proving the most successful, the data for that plat are used in the discussion and on the graphic charts. The yield per acre of 14.9 tons is slightly below the average of previous years, but the beet is very superior in quality, a result predicted before the analyses were made by reason of the character of the season. The content of sugar in the beet is 11.4, about 3 per cent higher than in previous years, and the purity is correspondingly higher, viz, 76.1, an increase of about 6 points. An explanation of this decided improvement in the quality of the beet is to be found in the moderate and evenly distributed temperature occurring in conjunction with an ideal distribution of the rainfall. There was no month of an unusually high temperature, the average for the season being 67.3° F., and for the three growing months, June, July, and August, 72.6°, one-tenth of a degree warmer for the season than in 1903, however, in which year no such improvement was seen. The distribution of the rainfall, therefore, must have played an important part in the change in the

beet. There was a sufficient precipitation in May to properly germinate the seed; June had a rainfall of 5.49 inches, an amount favorable to rapid growth; in July, the warmest month, the heaviest precipitation is recorded, viz, 6.25 inches; and during September and October it diminished decidedly, affording excellent conditions for the ripening and harvesting of the beets and precluding the possibility of any second growth at the expense of the sugar content. It is seen that these conditions leave nothing to be desired in regard to the proper growth and maturity of the beet, and they doubtless explain, in conjunction with the moderate temperature, the superiority of the beets over those of previous years. The season of 1903 had practically the same temperature, but did not have the ideal distribution of rainfall which characterized the season of 1904.

Agricultural and analytical data for beets grown on the Potomac flats, District of Columbia, in 1904, showing averages for different dates of planting.

Plat No.	Date of planting.	No. of beets in 50 feet of row.	Weight after topping.		Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
			Total.	Average.				
	1904.		*Pounds.*	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
1	May 6	68	46	10.5	11.7	11.7	10.9	72.1
2	May 13	57	50	14.1	12.8	12.1	11.4	75.7
3	May 20[a]	70	58	12.5	14.9	12.2	11.4	76.1
4	May 27	55	35	10.5	9.1	12.5	11.7	75.5

[a] Data for May 20 platted.

Meteorological data for Washington, D. C., 1904.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Percentage.		
	° *F.*	*Inches.*	*Hours.*	*Hours.*	*Per cent.*		
May	65.0	2.64	337.0	443.8	76	17	2
June	71.0	5.49	270.9	445.9	61	12	8
July	74.4	6.25	262.3	453.0	58	9	7
Averages and totals	70.1	14.38	.....	.....	65	38	17
August	72.3	2.44	208.9	423.2	49	10	10
September	67.4	1.71	208.3	373.4	56	10	5
October	54.1	.57	255.1	346.0	74	21	4
Averages and totals	64.6	4.72	.....	.....	59	41	19
General averages and sum totals	67.3	19.10	.....	.....	62	79	36

THE KENTUCKY STATION.

The sugar beets were grown on a rich loamy soil which had been thoroughly plowed and subsoiled to a depth of 16 to 20 inches. Before planting the seed, on April 22, the earth was thoroughly pulverized and put in perfect tilth by repeated harrowing and rolling. The seed was planted in 18-inch rows with a hand drill. A good stand was obtained, the beets coming up about May 5. When the

plants had four or five leaves, on June 1, they were thinned, leaving one or two plants every 3 inches. On the second date of thinning, June 13, they were thinned to one plant in every 9 inches. Three cultivations were given—on June 13, 21, and 27, the ground being kept free from weeds, and loose. The cultivation consisted of running a hand cultivator twice in the row and afterwards hoeing the plants. It was necessary to spray with arsenate of lead because of the presence of blister beetles.

Only two samples of beets were received for analysis, the data for which and the meteorological data for the growing season at Lexington are given in the following tables:

Agricultural and analytical data on beets grown at Lexington, Ky., and forwarded to Washington, D. C., for analysis, 1904.

Date of receiving samples at Washington.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
August 1	10.7	.....	12.2	11.30	70.8
August 1	9.0	.....	12.8	11.65	74.0
Average	9.8	[a]8.9	12.5	11.48	72.4

[a] Reported by stations.

Meteorological data for Lexington, Ky., 1904.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Percentage.		
	° *F.*	*Inches.*	*Hours.*	*Hours.*	*Per cent.*		
May	63.8	2.60	259.3	441.7	67	15	9
June	71.8	2.51	302.8	443.1	68	13	3
July	73.9	3.13	325.1	450.1	72	17	3
Averages and totals	69.8	8.24	.....	.....	69	45	15
August	74.2	2.44	310.4	422.1	74	15	4
September	69.4	1.71	280.3	373.0	75	12	5
October	57.0	.57	294.0	347.3	85	22	0
Averages and totals	66.9	4.72	.....	.....	78	49	9
General averages and sum totals	68.4	12.96	.....	.....	73	94	24

The estimated yield per acre at Lexington was quite low, namely, 8.9 tons. The percentage of sugar in the beet was considerably higher than in former years, reaching 11.5 per cent. The purity, however, was exceptionally low, being represented by the coefficient 72.4. The mean temperature from May to July inclusive was 69.8° F. and presents a very fair range for the three months; the average temperature from August to October was 66.9°, that of the three growing months, June to August, 73.3°. The average for the six months was 68.4°, a temperature favorable to the production of a beet with a reasonably high percentage of sugar. The rainfall,

although slightly deficient, was very evenly distributed, the smallest precipitation occurring in September and October, when it is least needed, and being therefore favorable to the production of a beet with a reasonably high percentage of sugar. The ratio of clear days to cloudy ones shows a remarkable freedom from heavy clouds. The number of clear days is almost four times that of the cloudy days reported. The percentage of sunshine is also very high. In spite of the small percentage of cloudy weather, the temperature was below normal. All conditions, therefore, combine, in so far as the meteorological data are concerned, to produce a crop of beets remarkably rich in sugar for that latitude and such a crop was actually produced.

THE MICHIGAN STATION.

The beets were planted at the Michigan Station on May 11, thinned on June 17, and sampled on October 15, 22, and 28. The weather was dry from July 8 to August 25, but otherwise the season was favorable. The following data were obtained on the three samples analyzed:

Agricultural and analytical data on beets grown at Agricultural College, Mich., and forwarded to Washington, D. C., for analysis, 1904.

Date of receiving sample at Washington.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
October 24	9.0	12.8	16.9	15.6	84.5
October 28	8.6	14.1	17.2	15.8	89.5
November 5	12.2	18.6	16.3	15.1	84.0
Averages	9.9	15.2	16.8	15.5	86.0

Agricultural data determined at the Michigan Station, 1904.

Date of sampling.	Beets in 50 feet of row.		Estimated yield per acre.
	Number	Total weight.	
		Pounds.	*Tons.*
October 15	69	50.0	14.5
October 22	69	55.0	16.0
October 28	55	57.5	.....
Averages	64	54.1	15.3

The yield per acre at the Michigan Station is very satisfactory, viz, 15.2 tons, notwithstanding the fact that the size of the beets is considerably less than a pound, averaging 9.9 ounces. The tonnage, high sugar content, 15.5 per cent, and high purity, 86, combine to make the production of the crop remunerative. The data on the yield as obtained at the Michigan Station are almost identical with the figures obtained at Washington.

The average temperature from May to July was 64.1° F.; from August to October, 58.8°; from June to August, 66.9°; and the average temperature of the six months was 61.5°. The warmest month was July, with an average temperature of 69.2°. August was much cooler, averaging 65.9°. The rainfall also was well distributed, with the exception of July, during which month the precipitation was below the normal. Both September and October, especially the former, show a precipitation which would have a tendency to continue growth and to stimulate it. However, it was not an excessive precipitation, and probably did not interfere greatly with the ripening of the beet. The other meteorological data are taken from the station at Detroit, and indicate an excess of cloudy weather. Upon the whole, the meteorological data may be considered favorable to the production of a beet of high quality.

Meteorological data for Agricultural College, Mich., 1904.

Month.	Mean temperature.	Precipitation.	Sunshine.[a]			Clear days.[a]	Cloudy days.[a]
			Actual.	Possible.	Percentage.		
	°F.	*Inches.*	*Hours.*	*Hours.*	*Per cent.*		
May	57.4	2.40	252.0	451.9	56	7	14
June	65.6	2.49	237.5	456.2	52	6	15
July	69.2	1.97	293.5	461.8	64	7	9
Averages and totals	64.1	6.86	.....	.....	57	20	38
August	65.9	3.26	307.1	429.4	72	16	4
September	[b] 62.0	2.35	227.0	374.5	61	8	7
October	48.6	1.90	167.2	342.5	49	8	14
Averages and totals	58.8	7.51	.....	.....	61	32	25
General averages and sum totals	61.5	14.37	.....	.....	59	52	63

[a] Data for Detroit, Mich., about 75 miles southeast of Agricultural College, the nearest point at which the sunshine data were observed.
[b] Ten days missing from record.

THE INDIANA STATION.

A very complete report was received from Mr. W. J. Jones, jr., of the Indiana Station, including a comparison of results obtained on fertilized and unfertilized plats. The unfertilized plat, No. 2, was reported as the one especially devoted to the cooperative work, and the average data obtained from the two unfertilized plats are used in the graphic charts. The following cultural data were reported:

CULTURAL DATA.

The dimensions of the plat were 98 by 248 feet, and the area 0.56 acre.

April 29.—Ground plowed to depth of 9 inches and harrowed. Soil and subsoil sampled and samples forwarded to Washington.

May 7.—Soil harrowed both ways and broken with clod crusher. Beets planted; rows 18 inches apart. Day warm and partly cloudy. Soil in excellent condition; temperature of soil 66° F.

May 16.—Beets coming through. Stand apparently good.

May 23.—Beets all up. Stand thick with a few barren spots. Owing to low temperature and cold rains beets have made but little progress since coming up. Seed seems to have all germinated.

May 25.—Beets very weedy. Cultivated with hand cultivator.

May 27.—Beets doing nicely. Fourth leaf appearing, but plants too small to thin. Rows at edge of field are being attacked by cutworms

June 2.—Ground full of cutworms which have destroyed many plants. Transplanted beets to all spaces of 9 inches or over. Day partly cloudy, temperature moderate, soil hard but moist All conditions favorable for successful transplanting. Transplanted only healthy plants in bunches; used transplanter and making deep holes. Thinned plants to clumps of 3 inches with 6-inch spaces between clumps. Stand excellent All weeds removed with hoe and soil loosened around beets.

June 4.—Weeding of plants finished. Transplanted plants doing nicely, and entire field making great progress.

June 9.—Plants in good condition, but show need of rain. Cutworms still working.

June 11.—Need of rain still apparent. Field cultivated and free from weeds.

June 14.—Plants making rapid growth; thinned to 9 inches, and weeds removed from between plants.

June 20.—Plants growing rapidly. Stand excellent, but a little irregular as to size of plants. Plants have 10 leaves. Soil in excellent condition. Cucumber bugs in field. No loss from transplanting.

June 22.—Beets cultivated.

June 27.—Plants in excellent condition, and have made rapid progress since June 22. Plants practically the same size in all parts of field. Stand perfect. Field clean and soil in fine condition. Plants large enough to shade the ground. Cucumber bugs have done little damage.

June 30.—Part of field hoed. Hail storm cut leaves badly, but the damage is not serious.

July 2.—Balance of field hoed and weeds removed from between plants in part of field.

July 9.—Weeding of plants concluded. Plants in fine condition, and leaves broken by hail are still large enough to shade ground.

July 17.—Condition of plants very satisfactory. Ground baking and needs cultivation.

July 19.—Beets cultivated.

July 25.—Field in fine condition and beets making good growth: foliage much larger. Rain would be beneficial.

July 30.—Beets showing effect of drought and wilting badly; growth good, but the need of rain very apparent.

August 3.—Effect of drought very marked; leaves badly wilted and turning yellow.

August 7.—Plants making some progress, but drought is delaying growth and leaves are gradually falling off. Huston's Evil Eye making its appearance.

August 14.—Ground so dry it has begun to crack. Plants making but little progress.

August 21.—Plants show little change in condition from report of preceding week.

August 23.—Field hoed and very clean.

August 24.—Large black bug (blister beetle) eating the foliage.

August 25.—Sprayed field with arsenite of soda and bug disappeared.

August 28.—Plants and soil in fine condition. Very clean; no bugs. Rain produced marked improvement.

September 4.—Field clean and in satisfactory condition. Effect of drought still apparent. Many leaves turning brown, which may be due to arsenite.

September 11.—Beets making good progress. Other conditions almost as on the 4th.

September 19.—Marked improvement since the 11th. Dead leaves disappearing and foliage green and bright. Beets were evidently stunted by drought.

September 25.—Entire field shows marked improvement in every particular.

October 2.—Improvement continues, especially noticeable in appearance of leaves which are making a new growth.

October 9.—Field almost as on October 2.

October 11.—Samples taken to-day following rain on 10th. Ground very hard at a depth of 4 inches. Beets show a tendency to form subdivided roots and are hardly up to the average in size and shape.

October 15.—Fifty feet of fourth row of beets removed for first sample and forwarded to Washington.

With the first sample of beets, forwarded under date of October 15, the following comments were made:

We were unable to have the ground subsoiled, and this, in my opinion, has been slightly detrimental. The stand, however, is the best that we have had in years, though the dry weather in July and August resulted in smaller beets; in fact, for three or four weeks their growth seemed to be entirely checked, and the effect of the drought was seen in the wilting and dying of the leaves.

There was a marked difference between the beets grown on the unfertilized and fertilized plats, the latter standing the drought much better and presenting a better appearance, both as to foliage and growth, throughout the season.

The beets showed the same tendency as in 1903, to have subdivided roots—sometimes as many as four prongs being formed. This may have been due to lack of subsoiling, though in 1903 the ground was subsoiled at the proper time.

The weather is quite mild and conditions at present are not favorable for an early maturing of the beets since we have as yet had no severe frosts.

On October 24 five samples of beets were sent, three of which (plats 1, 3, and 5) were grown with fertilization and the others without. The description of these plats and their fertilization is as follows:

Plat 1.—Ten rows, 18 inches apart, making 0.09 of an acre. On May 17, when beets were just up, the following materials were applied: 10.5 pounds of nitrate of soda, 12.9 pounds acid phosphate, 3.6 pounds of potassium sulphate. On June 9 and 20 the application was repeated.

Plat 2.—Regular experimental plat from which sample was sent on October 15. Ten rows, 18 inches apart; no fertilizer applied.

Plat 3.—Eight rows, 22 inches apart. Same fertilizer applied as in the case of plat 1 and on the same dates.

Plat 4.—Eight rows, 22 inches apart. No fertilizer applied.

Plat 5.—On May 17 the following fertilizer was applied: 10.5 pounds of nitrate of soda, 5 pounds of bone, and 3.6 pounds of potassium sulphate. On June 9 this application was repeated, and on June 20 the following fertilizer was applied: 10.5 pounds of dried blood, 5 pounds of bone, and 3.6 pounds of potassium sulphate.

The following comments on the conduct of the work were reported on this date (October 24):

The total amount of plant food applied to the fertilized plats was 3 pounds of nitrogen in the nitrate of soda, 1.5 pounds of nitrogen in dried blood, 5.4 pounds of phosphoric acid, and 4.5 pounds of potash (K_2O). The bone contained 35.8 per cent of total phosphoric acid soluble in citrate and is therefore essentially a dicalcium phosphate.

The cultural data for all the plats are the same and have been previously given. It was a very noticeable fact throughout the season that the fertilized plats stood the drought much better than the unfertilized, and this was especially true of plat No. 5, to which the bone

was applied. At no time were there any dead leaves on this plat and the foliage remained green, not wilting as on the other plats.

The weather since October 15 has varied from hot to cold with irregular rains, and has not been of a nature to hasten the maturing of the beets.

Plats 3 and 4 are on somewhat lower ground than the others, and seem to be making a new growth. Two check rows are left between each plat.

YIELD AND CHARACTER OF BEETS HARVESTED.

A sample from plat No. 2 only was forwarded under date of October 28, accompanied by the following comments:

The weather the past week has been favorable to the maturing of the beets. There have been three killing frosts, and the days, while clear, have been moderate in temperature, the maximum being about 57°. The beets in all the plats show an increase in sugar, plat No. 1 leading with 16 per cent of sugar in the juice. Other conditions remain about the same as when the last report was made.

Under date of November 14, the following report was made on the samples shipped on November 6 and 11:

The beets during the past week have shown such an increase in sugar content that it seemed wise to send a sample from each of the plats, which was done on November 11. Until the past three or four days we have had no severe weather, but I think the beets have reached their maximum development.

I inclose a weather summary for the period covering the experiment. The amount of sunshine per day is of course estimated and can not be considered as exact. I have figured the sunshine from 6 a. m. to 6 p. m. during the entire period. It is probable that the average would not be far from this figure.

On November 26 the final report was made, as follows:

On November 18 a sample of beets was taken and the results were such that it seemed useless to continue the work any longer. In calculating the yield of beets this year it seems fair to base it upon the average of the samples taken from the different plats on November 4, 10, and 18. On this basis my estimate is as follows:

Plat No. 1, 12.8 tons per acre; No. 2, 10.5 tons; No. 3, 11.3 tons; No. 4, 8.5 tons, and No. 5, 12.5 tons per acre.

It will of course be remembered in using these figures that on plats 1 and 2 the rows were 18 inches apart while on Nos. 3, 4, and 5 they were 22 inches apart.

The illustrations (Plate I) show 10 beets from the experimental plat sampled on November 10, and also 10 of the imperfect beets, showing the tendency to multiplicity of roots manifested at the Indiana station during the past two years. These beets averaged 7.5 ounces in weight before capping and 6.4 ounces afterwards; there was 16.8 per cent of sugar in the juice and a purity of 83.6.

ANALYTICAL AND AGRICULTURAL DATA.

The analytical and agricultural data determined both at the Bureau of Chemistry and at the station are given in the following tables:

Agricultural and analytical data on beets grown at Lafayette, Ind., and forwarded to Washington, 1904.

Number and description of plats.	Average weight after topping.[a]	Estimated yield per acre.[b]	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
No. 1. Fertilized	9.4	11.2	17.5	15.9	85.6
No. 2. Unfertilized[c]	7.7	9.2	16.1	14.9	85.6
No. 3. Fertilized	8.5	10.1	17.3	15.9	85.5
No. 4. Unfertilized	8.8	7.4	16.7	15.2	86.0
No. 5. Fertilized	11.1	11.8	16.9	15.4	84.7
Average of fertilized plats	9.5	11.0	17.2	15.7	85.3
Average of unfertilized plats	8.3	8.3	16.4	15.1	85.8

[a] Data determined on 25 beets shipped to Bureau of Chemistry for analysis.
[b] Based on samples harvested November 4, 11, and 18.
[c] No. 2 is the experimental plat proper, and the average determined for the two unfertilized plats is used in making the graphic chart.

Averages of agricultural data reported by the Indiana Station, 1904.

Plat No.	Average.	No. of beets in 50 feet of row.	Weight after topping.		Yield per acre.	Loss in capping.	Yield tare.
			Total.	Average.			
			Pounds.	*Ounces.*	*Tons.*	*Per cent.*	*Tons.*
1	General	63	44.4	11.4	12.9	17.3	10.6
	November 4–18		43.7	11.4	12.7		
2	General	61	35.3	9.3	10.3	16.5	8.5
	November 4–18		35.9	9.4	10.4		
3	General	65	47.9	11.8	11.4	18.3	9.3
	November 4–18		47.6	11.7	11.3		
4	General	59	32.6	9.0	7.8	17.0	6.5
	November 4–18		34.5	8.6	8.2		
5	General	59	53.5	14.4	12.7	20.1	10.2
	November 4–18		55.4	13.9	12.4		

Average yields of fertilized and unfertilized plats[a] as reported by the station.

Average.	Fertilized plats, Nos. 1, 3, and 5.			Unfertilized plats, Nos. 2 and 4.		
	Average weight.	Yield per acre.	Yield tare.	Average weight.	Yield per acre.	Yield tare.
	Ounces.	*Tons.*	*Tons.*	*Ounces.*	*Tons.*	*Tons.*
General	12.8	12.3	10.0	9.2	9.1	7.5
November 4–18	12.3	12.1		9.0	9.3	

[a] Plats 1 and 2, rows 18 inches apart; plats 3, 4, and 5, 22 inches apart.

Analytical data determined at the Indiana Station, comparing fertilized and unfertilized plats, 1904.

Date of sampling.	Plat 1, fertilized.		Plat 2, unfertilized.		Plat 3, fertilized.		Plat 4, unfertilized.		Plat 5, fertilized.	
	Sugar in juice.	Purity coefficient.	Sugar in juice.	Purity coefficient.	Sugar in juice.	Purity coefficient.	Sugar in juice.	Purity coefficient.	Sugar in juice.	Purity coefficient.
	Per ct.		*Per ct.*		*Per ct.*		*Per ct.*		*Per ct.*	
October 11			14.0	91.6						
October 22	14.2	84.6	14.1	93.4	13.0	85.2	13.2	89.4	14.3	89.0
October 28			14.6	86.0						
November 4	17.4	87.2	16.2	91.6	16.0	88.3	15.5	88.8	14.7	88.8
November 10	18.5	89.6	16.0	90.2	15.9	89.5	16.8	90.9	16.4	88.7
November 18	18.3	90.3	16.6	90.4	16.4	91.3	16.3	90.2	15.0	89.7
General average	17.1	87.9	15.3	90.5	15.3	88.6	15.5	89.8	15.1	89.1
Average November 4–18	18.1	89.0	16.3	90.7	16.1	89.7	16.2	90.0	15.4	89.1

Average analytical data for fertilized and unfertilized plats, as determined at the Indiana station, 1904.

Average.	Fertilized plats, Nos. 1, 3, and 5.		Unfertilized plats, Nos. 2 and 4.	
	Sugar in juice.	Purity coefficient.	Sugar in juice.	Purity coefficient.
	Per cent.		*Per cent.*	
General	15.8	88.5	15.4	90.2
November 4–18	16.5	89.3	16.3	90.4

Full details of the cultural data at the Indiana Station are given in the report of the special agent in charge. The average yield of the unfertilized plats was low, namely, 8.3 tons per acre. The yield of the fertilized plats was higher, 11 tons, but not so large as should be obtained. The percentage of sugar in the beets was very high, both from the fertilized and unfertilized plats, and the purity was exceptionally high. The data used in platting the results of the work were obtained on plats Nos. 2 and 4. The analytical data obtained at the Bureau of Chemistry compare very closely with those obtained at the Indiana Station, with the exception of the coefficients of purity. Uniformly, the results for purity obtained at Lafayette have been higher than those found at the Bureau of Chemistry, and this difference has not as yet been satisfactorily explained.

METEOROLOGICAL DATA.

The meteorological data indicate a favorable environment in so far as the temperature is concerned, for the production of a beet with a high content of sugar. The average temperature of the months from May to July, inclusive, is 67.8° F., and from August to October, 62.8°; from June to August, 70.7°; the mean temperature for the six months being 65.3°. The precipitation at the Indiana station

was well distributed for the proper growth and maturity of the beet, except during the month of September, when the rainfall was excessive. A very dry October, however, counteracted this excess, and thus brought the crop to a very fair maturity. In general, the meteorological data for the Indiana station for 1904 must be regarded as extremely favorable and apparently should have produced a larger yield per acre than was secured.

Meteorological data for Lafayette, Ind., 1904.

Month.	Mean temperature.	Precipitation.	Sunshine.	Clear days.	Cloudy days.
	°F.	*Inches.*	*Per cent.*		
May	61.4	2.98	47.0	5	20
June	69.6	2.05	70.0	7	19
July	72.3	6.12	80.9	15	10
Averages and totals	67.8	11.15	66.0	27	49
August	70.2	2.40	73.4	11	11
September	66.2	4.41	56.4	7	20
October	52.0	.78	67.9	17	13
Averages and totals	62.8	7.59	65.9	35	44
General averages and sum totals	65.3	18.74	66.0	62	93

THE NEW YORK STATION (GENEVA).

At the Geneva Station one-eighth of an acre was sown for the cooperative work on June 11, 20 inches between the rows, thinned on July 9 so as to leave the plants from 8 to 10 inches apart, and harvested on November 8. No samples were sent to the Bureau of Chemistry for analysis, but the following data were obtained at the station at the time of harvest:

Agricultural data:

Weight of 50 beets	pounds	56.3
Weight of 50 beets capped	do	45.0
Yield per acre	tons	19.0

Analytical data:

Sugar in juice	per cent	17.0
Sugar in beet	do	13.7
Coefficient		83.7

About 250 analyses of individual beets selected by the appearance of the tops before digging gave a sugar content of 17.7 per cent, while about 300 such analyses of beets selected at the same time from the appearance of the roots gave a sugar content of 18.1 per cent.

The beets grew very vigorously, holding their leaves until the harvest. No leaf spot or other diseases appeared. The meteorological data obtainable for Geneva are as follows:

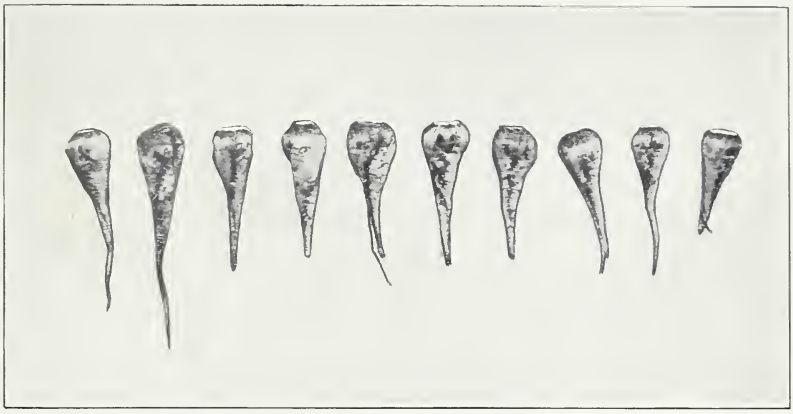

FIG. 1.—TEN BEETS HARVESTED FROM THE EXPERIMENTAL PLAT NO. 2, INDIANA STATION, NOVEMBER 10, 1904.

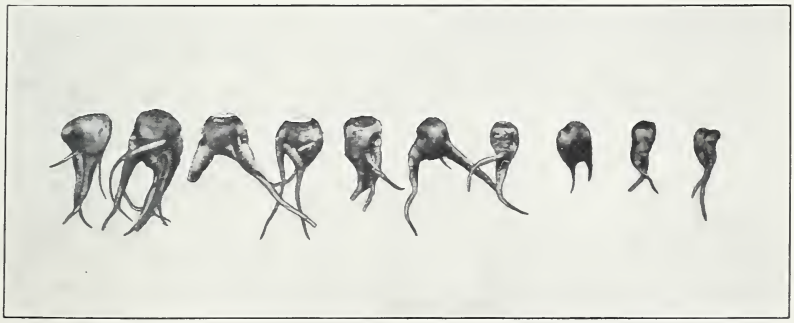

FIG. 2.—BEETS SHOWING THE TYPICAL MALFORMATION OF ROOTS AT THE INDIANA STATION.

Meteorological data for Geneva, N. Y., 1904.

Month.	Mean temperature.	Precipitation.	Sunshine.[a]	Clear days.[b]	Cloudy days.[b]
	°F.	*Inches.*	*Per cent.*		
May	60.3	4.04	63.0	19	9
June	67.8	3.37	66.0	18	9
July	70.0	5.73	63.0	18	10
Averages and totals	66.0	13.14	64.0	55	28
August	68.2	2.56	74.0	19	8
September	61.9	3.26	57.0	.....	.....
October	48.4	2.06	48.0	15	9
Averages and totals	59.5	7.88	59.0	34	17
General averages and sum totals	62.8	21.02	61.5	89	45

[a] Data for Rochester, N. Y., about 40 miles northwest of Geneva.
[b] Data for Lyons, N. Y., about 13 miles northwest of Geneva.

The estimated yield per acre at Geneva was very high, namely, 19 tons. The reported percentage of sugar in the beet is quite low when compared with the reported percentage of the sugar in the juice. There appears to be a discrepancy here which is not explained. The mean temperature for May to October, 62.8° F., is divided into that for May to July, 66°, and August to October, 59.5°, while that for the three growing months of June, July, and August was 68.7°. The temperature was not very high at any time, July having the highest average, namely, 70°, while August had a markedly lower temperature, 68.2°. The precipitation was excessive in May and July, and conducive to growth during the other months. There was a greater amount of rainfall in September and October than was desirable for the proper maturity of the beets, and it appears that the growth must have been checked by the cool weather of October rather than by lack of moisture. The other meteorological data not obtainable for Geneva were taken from Rochester and Lyons. In general, the meteorological data appear favorable to the production of a beet of high quality, and in fact the purity of the beet is represented by the coefficient of 83.7.

THE NEW YORK STATION (ITHACA).

Under date of September 13, when sending the first sample, the following comments on the year's experiment were made:

These beets were not sown until the middle of June. This was the second sowing, the first having been a failure, which may account for the small yield—7.6 tons per acre. As half the plat was in sugar beet last year and the other half was not, I should like to send two samples for sugar determinations, for comparison. Leaf spot was present last y ar and made its appearance this year about the last of August on the half of the plat which was in sugar beets before, spreading gradually in about two weeks to the other end of the plat. This may affect the quality of the roots.

The two sets of samples were received and analyzed, the average only being given in the table in case of that part of the plat which was newly planted in beets. It will be noted that the beets from the latter were superior in every respect, there being a difference of 1.6 tons in yield, 1.9 per cent in sugar in the beet, and 4.3 in the purity coefficient.

Agricultural and analytical data on beets grown at Ithaca, N. Y., and forwarded to Washington, 1904.

PART OF PLAT IN BEETS BEFORE.

Date of receiving sample at Washington.	Average weight after topping.	Estimated yield per acre.[a]	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
September 17	5.6	.....	12.3	11.0	74.4
September 28	5.1	.....	12.4	11.4	76.0
October 1	5.1	.....	12.7	11.2	76.1
October 10	4.5	.....	13.5	12.4	74.6
October 17	6.4	.....	13.2	12.3	72.9
October 24	6.4	.....	17.3	15.8	82.4
October 28	8.0	.....	14.3	13.0	76.9
Averages	6.0	7.6	13.7	12.4	76.2

PART OF PLAT NEWLY PLANTED TO BEETS.

Averages	7.1	9.2	15.6	14.3	80.5

[a] Data determined at the station.

The yield per acre at the Ithaca Station was remarkably low, being only 7.6 tons on that portion of the plat which had been used for beet cultivation throughout the experiment, and 9.2 tons on the newly planted portion, both figures having been determined at the station. The percentage of sugar in the beet was satisfactory, being 12.4, but the purity of 76.2 is considerably below the standard, and combined with the low tonnage would not yield a very profitable return. The data for the portion of the plat used throughout the experiment are platted, and it is to be noted that the use of the data from the newly planted portion would have placed Ithaca above Geneva in the comparative charts; the inferiority in purity and tonnage, however, would make the crop as a whole still inferior to that produced at Geneva.

The average temperature from May to July was 64.5° F.; from June to August, 67.8°; from August to October, 58.7°; and for the six months, 61.6°. The precipitation was rather irregular, being greatest in May, when it was least needed, and smallest in August, when it was most needed. The beets must have suffered considerably in their development by the excessively dry weather of August and September. There was in general a predominance of cloudy days over the number of clear days. The conditions of temperature as indicated are favorable to the production of a beet of high character, but the

precipitation was not so distributed as to favor the production of a large crop.

Meteorological data for Ithaca, N. Y., 1904.

Month.	Mean temperature.	Precipitation.	Clear days.	Cloudy days.
	°F.	Inches.		
May	59.6	4.64	6	16
June	65.6	1.77	7	11
July	68.4	3.79	9	8
Average and totals	64.5	10.20	22	35
August	69.4	1.85	16	4
September	59.6	1.93	8	10
October	47.2	2.71	10	14
Average and totals	58.7	6.49	34	28
General average and sum totals	61.6	16.69	56	63

THE NORTH CAROLINA STATION.

The experiment conducted by the North Carolina Station was practically a failure, owing to the very unfavorable weather conditions, a long drought following the sowing on May 25 and 30, preventing germination for about three weeks, and another one of eight weeks' duration occurring in September and October. The beets were thinned on June 27 and July 9 and harvested on December 20, one sample being sent then and one on January 11, after the beets had been held in storage. The beets were grown at the test farm at Statesville, about 138 miles due west of Raleigh, the western part of the State being more favorable to this crop. In August there was considerable rain, and the plant made a start, only to be checked by the drought of September and October, most of the growth being made still later in the fall. The high quality of the crop, as shown by the analyses of the two samples sent, is to be attributed to the small size of the beets.

Agricultural and analytical data on beets grown at Raleigh, N. C., and forwarded to Washington, 1904.

Date of receiving sample at Washington.	Average weight after topping.	Estimated yield per acre.[a]	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	Tons.	Per cent.	Per cent.	
December 27, 1904	6.5	.....	15.4	14.0	80.61
January 14, 1905[b]	6.7	.....	16.4	14.9	82.01
Averages	6.6	1.5	15.9	14.5	81.31

[a] Estimate reported by station.
[b] Harvested December 20, on same date as the first sample, stored, and shipped January 11, 1905.

Meteorological data for Statesville, N. C., 1904.

Month.	Mean temperature.	Precipitation.	Sunshine.[a]	Clear days.	Cloudy days.
	°F.	*Inches.*	*Per cent.*		
May	65.2	2.07	64	11	3
June	72.4	5.74	59	8	5
July	74.6	4.01	48	7	2
Averages and totals	70.7	11.82	57	26	10
August	74.2	6.60	45	5	11
September	[b] 69.4	1.31	64	10	4
October	56.8	.12	84	21	3
Averages and totals	66.8	8.03	64	36	18
General averages and sum totals	68.8	19.85	61	62	28

[a] Data for Asheville, N. C., about 97 miles west of Statesville
[b] Four days missing.

The failure to obtain a crop at the North Carolina Station renders the discussion of the fragmentary data unnecessary. Although the germination of the crop was prevented by a severe drought in May, an inspection of the data for the precipitation will not indicate the severity of the disaster. The precipitation for May was sufficient, had it been properly distributed, to have secured germination, and for June it was very abundant. There was an abundant rainfall, as far as quantity is concerned, also in July and August. September was quite dry, and during October only twelve-hundredths of an inch of rain fell. An inspection of the data for temperature shows high temperatures for June, July, and August, averaging 73.7° F.—considerably above the limit suitable for the production of a beet rich in sugar. The high content of sugar in the beets, as before stated, must be attributed to their stunted growth, the beets being extremely small, and the yield only about 1½ tons per acre. It is a common experience that beets of this character always contain abnormal percentages of sugar.

THE VIRGINIA STATION.

The seed was planted at the Virginia Station on April 14, and the plants were cultivated at frequent intervals throughout the growing season, being thinned on June 16 and sampled on September 14 and 26 and October 8 and 21. The germination was reported as being almost perfect and the plants made a rapid growth, reaching full size about August 1, when the outer leaves began to turn dark and become dry. Later the beets made a second growth, which was checked by two weeks of dry weather the first part of September. The season, as a whole, is reported as being favorable, with much rain.

Agricultural and analytical data on beets grown at Blacksburg, Va., and forwarded to Washington, 1904.

Date of receiving sample at Washington.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
September 20	9.9	10.7	14.7	13.5	80.6
October 1	9.0	.....	14.7	13.4	81.7
October 12	10.9	16.7	15.0	13.8	80.2
October 28	9.3	12.6	15.5	14.5	82.5
Average	9.8	13.3	15	13.8	81.2

Agricultural data determined at Blacksburg, Va., 1904.

Date of sampling.	Beets in 50 feet of row.		Estimated yield per acre.
	Number.	Total weight.	
		Pounds.	*Tons.*
September 15	69	45.0	13.1
September 27	.....	.....	14.5
October 10	65	57.3	16.7
October 22	49	34.8	10.1
Average	61	45.7	13.6

Meteorological data for Blacksburg, Va., 1904.

Month.	Mean temperature.	Precipitation.	Clear days.	Cloudy days.
	°*F.*	*Inches.*		
May	58.8	2.38	7	12
June	68.0	7.42	4	8
July	69.4	4.13	6	9
Average and totals	65.4	13.93	17	29
August	69.2	4.00	2	12
September	64.2	.27	.....	.....
October	52.4	.13	.....	.....
Average and totals	61.9	4.40	2	12
General average and sum totals	63.6	18.33	19	41

The data for the station at Blacksburg are interesting, because of the high altitude of the experimental field. This high plateau, by reason of its altitude, tends to correct the unfavorable features of an environment so far south for the growth of beets. The yield was satisfactory, although the beets were below the normal in size, the average weight before topping being 11.8, and after topping 9.8 ounces. The content of sugar was satisfactory, namely, 13.8 per cent, and the purity above the standard, being 81.2. The temperature data show in a striking manner the effect of the altitude. The mean temperature for May to July was 65.4° F.; August to October, 61.9°; for the six months, 63.6°; and for the three growing months, 68.9°. The precipitation was abundant during the greater part of the growing season. Although May was somewhat dry, June shows

an excessive rainfall, while July and August had an excessive rainfall as far as the needs of growth were concerned, and September and October were dry, thus favoring early maturity. The cloudy days far exceeded the clear ones; and it will be noticed that at no time did the temperature reach 70°, although July had a temperature of 69.4°. The conditions, in so far as temperature and precipitation were concerned, were very favorable to the production of a crop not only of fair size, but also of excellent quality.

THE WISCONSIN STATION.

Mr. F. W. Woll, of the Wisconsin Station, furnished, as usual, a very complete report of the sugar-beet work conducted at Madison, extracts from which report are given as follows:

About two-fifths of an acre of land was set apart for sugar-beet work in the spring of 1904, on a part of the same field on which sugar beets were grown last year. The field was plowed on April 24, dragged twice on April 29 and on April 30, and a fine seed bed was prepared by disking and harrowing on May 20. The beets were planted on the same day in drills 18 inches apart, and were thinned on June 15 to approximately 8 inches apart in the row. The beets were kept free from weeds during the growing period by wheel hand cultivator and hoe, the field being laid by on July 22.

The growth of the beets was very satisfactory during the early part of the season, when both the moisture and temperature conditions were favorable. Abundant moisture was also supplied during the months of August and September, but a short intermediate period of hot sultry weather occurred in the early part of August, which affected the beets injuriously, causing the leaves to droop and the lower ones to turn yellow, as if some fungous disease had attacked the plants. During the latter part of the growing period many new leaves appeared and the plants seemed to take on new life. This condition, in all probability, accounts for the relatively low sugar content and the low purity of the beets during the early fall months, as shown by the results of the chemical analyses made during September and October.

The sampling of the beets was begun on September 20 and was continued weekly until October 25, when the crop was harvested. The sugar contents of the samples dug from September 20 to October 17 were as follows: 12.77 per cent, 12.64 per cent, 12.33 per cent, 13.48 per cent, and 13.32 per cent. The estimated yields per acre ranged from 20.5 to 30.4 tons. The data obtained at harvesting time gave the following averages: Estimated yield per acre, 25.7 tons; sugar in the beet, 14.6 per cent; and purity coefficient, 87.1.

While the plan of growing sugar beets on the same land for several years in succession is not to be recommended, the results obtained show that under favorable climatic conditions and on land in a high state of fertility strong and healthy beets may be grown for a limited time without a change of crops in the successive seasons. During the past three years the yields obtained on the University farm have exceeded 25 tons to the acre, and the yields of sugar have exceeded 3 tons to the acre.

The following data obtained at the Bureau of Chemistry do not run quite as high as those obtained at the station, but still represent a very satisfactory crop:

Agricultural and analytical data on beets grown at Madison, Wis., and forwarded to Washington, 1904.

Date of receiving sample at Washington.	Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Ounces.	*Tons.*	*Per cent.*	*Per cent.*	
September 28	13.4	20.7	13.2	12.0	80.0
October 1	16.6	.....	13.5	12.2	82.3
October 10	14.9	16.4	12.9	12.1	81.1
October 17	13.4	.....	13.3	12.4	82.6
October 24	14.7	22.5	15.3	14.2	82.7
November 5	13.4	.....	15.7	14.5	84.4
Averages	14.4	19.9	13.9	12.9	82.2

Agricultural data reported by station, 1904.

Date.	Beets in 50 feet of row.		Estimated tonnage.
	Number.	Total weight.	
		Pounds.	*Tons.*
September 20	79	70.5	.....
October 4	60	62.5	18.1
October 12	.....	.....	23.7
October 18	70	87.5	25.4
October 31	.....	.....	25.0
Average	70	73.5	23.1

Meteorological data for Madison, Wis., 1904.

Month.	Mean temperature.	Precipitation.	Clear days.	Cloudy days.
	° *F.*	*Inches.*		
May	57.4	5.03	10	13
Jun	65.7	2.85	12	13
July	69.4	3.27	8	8
Average and totals	64.2	11.15	30	34
August	66.9	3.20	6	4
September	61.4	5.93	10	14
October	50.7	1.71	15	7
Average and totals	59.7	10.84	31	25
General average and sum totals	62.0	21.99	61	59

The agricultural data show a fine yield per acre, namely, 19.9 tons, and the beets are of a satisfactory size, the average weight after topping being 14.4 ounces. The sugar content is not quite so high as would be expected under the circumstances, but the purity is very satisfactory, 82.2. The mean temperature from May to July was 64.2° F., from August to October 59.7°, for the three growing months 67.3°, and for the six months 62°. The warmest month was July, with a temperature of 69.4°, while August was only slightly warmer

than June. The precipitation was overabundant during May and September, and it is more than probable that this excessive rainfall in September maintained the beets in vigorous growth, and to this cause the rather low content of sugar may be attributed. These data show in a striking manner how the distribution of the rainfall may serve to influence the sugar content even though the conditions of temperature tend to produce a high percentage of sugar. The number of clear days was slightly larger than that of the cloudy days at this station, notwithstanding the amount of rainfall.

EXPERIMENTS CONDUCTED IN IRRIGATED SECTIONS.

THE CALIFORNIA STATION.

The peculiar conditions existing at the California Station, together with the distance of the station from Washington, made it impracticable to conduct the experiment along the lines followed in regard to eastern locations, and therefore no analyses were made at Washington (except of the soils), and the report of Mr. G. W. Shaw, in charge of the cooperative work at the station, is submitted in full:

As in former years the beet plat on the Pomona substation tract comprised one-tenth of an acre. The ground was plowed, graded, and irrigated on February 24, 1904, after a comparatively dry season, as will be seen by reference to the climatic data. After plowing, the plat was thoroughly harrowed and worked to a good seed bed according to instructions. The seed was sown on March 2, in drills 18 inches apart, and a good stand was showing on March 10. The beets were thinned on April 15 leaving the plants 8 inches apart in the row.

Irrigation began on May 14, the water being applied as follows:

Irrigation data, Pomona, Cal., 1904.

Date of irrigation.	Amount of water remaining on plat.		
	Gallons.	*Cubic feet.*	*Acre-inches.*
May 14	10,000	1,336	0.37
May 30	8,000	1,069	.29
June 3	10,000	1,336	.37
June 11	6,000	802	.22
June 18	5,000	668	.19
June 27	4,000	534	.14
July 5	3,000	401	.11
July 12	2,500	334	.09
Totals	48,500	6,480	1.78

Irrigation was discontinued after July 12, as the beets appeared to be mature, but on September 13, about 5,000 gallons were used to soften the ground, which had become quite hard and dry. This amount, however, should not be counted as a part of the irrigation which influenced the crop, as the beets were plowed out on September 15, and pulled and weighed on September 19. The natural precipitation during the preceding fall and spring (that is, from September 27, 1903, to February, 1904, inclusive) amounted to 2.51 inches, and during the growing season (March to September), 6.74 inches, a total rainfall of 9.25 inches, which with the 1.78 inches of water received by irrigation gives a sum total of 11.03 inches, of which amount 8.52 inches were received after planting.

While the fall was dry and rather unfavorable the spring rains were well distributed and the season would be considered fair for the locality. Nearly all the moisture of the season was applied after planting, whereas the reverse was the case in 1902. The effect is quite noticeable, double the crop being secured this season. The meteorological data are as follows:

Meteorological data for Pomona, Cal., 1904.

Month.	Mean temperature.	Precipitation.	Sunshine.			Clear days.	Cloudy days.
			Actual.	Possible.	Percentage.		
	° F.	*Inches.*	*Hours.*	*Hours.*	*Per cent.*		
March	57.0	5.16	200	320	62.5	16	13
April	61.0	1.21	300	340	88.2	22	8
May	66.0	.18	310	430	72.1	25	6
Averages and totals	61.3	6.55	.....	.....	74.3	63	27
June	72.0	.00	380	440	86.1	30	0
July	74.0	.00	(a)	(a)	(a)	31	0
August	77.0	.19	340	400	85.0	29	2
September	73.0	Trace.	255	360	70.8	28	2
Averages and totals	74.0	.19	.....	.....	80.7	118	4
General averages and sum totals	67.7	6.74	.....	.....	77.5	181	31

(a) Data missing.

Each irrigation was followed by a thorough cultivation as soon as the ground was in condition to be worked. The agricultural data are as follows:

Agricultural data regarding beets grown at Pomona, Cal., 1904.

Date of harvest		September 29
Date of analysis		October 5
Relation of tops to beets at harvest	per cent.	17.00
Weight of 6 topped beets at harvest	ounces.	97.75
Weight of 6 topped beets when analyzed	do.	92.00
Loss from drying	do.	5.75
Loss from drying	per cent.	6.90
Average weight of beets as analyzed	ounces.	15.17
Estimated yield per acre	tons.	10.50

As it is evident from these figures that the beets lose almost 7 per cent of their weight by drying in the time which elapses before they reach the laboratory, the results of the analyses as determined and as calculated to the original weight of the samples are given.

Analytical data determined at the Berkeley (Cal.) Station, 1904.

Data.	Density.	Sugar in juice.	Sugar in beet.(a)	Purity coefficient.
	° Brix.	*Per cent.*	*Per cent.*	
Result of analysis	19.71	15.50	14.26	78.63
Corrected to original weight	18.44	14.50	13.34	78.63

(a) The factor 92 used as determined by the hot aqueous method.

The sugar content is lower by about 1 per cent than that of 1902 and the purity is nearly 8 points lower. This may have been due to the rains occurring on August 19, at which time 0.19 inch fell, but it hardly seems possible that the beets would not have fully recovered from this during the thirty days of hot weather that followed. The purity is very low as compared with that of the beets generally received from the same locality.

To test the efficiency of single sampling, as practiced this year in representing the average of the plat, as well as for the purpose of noting the variation in the sugar content between contiguous beets, 30 consecutive single beets were taken from the same row and sent to the laboratory, numbered according to their positions in the row, and the sugar in the beet was determined. The results are as follows:

Analyses of single beets taken from the same row, 1904.

Consecutive numbers in row.	Weight of topped beet.	Loss of weight by drying.	Sugar in the beet.		Consecutive numbers in row.	Weight of topped beet.	Loss of weight by drying.	Sugar in the beet.	
			As analyzed.	Calculated to original weight.				As analyzed.	Calculated to original weight.
	Ounces.	*Per cent.*	*Per cent.*	*Per cent.*		*Ounces.*	*Per cent.*	*Per cent.*	*Per cent.*
1	5.3	9.9	15.2	13.8	17	9.3	[d]	[d]	[d]
2	9.5	7.0	19.0	17.7	18	13.4	7.3	12.6	11.7
3	[b] 9.2	8.4	14.6	13.5	19	12.7	16.9	15.6	13.4
4	41.3	6.0	Lost.	Lost.	20	8.6	15.8	17.2	14.8
5 [a]					21	11.9	2.6	16.1	15.7
6	19.7	3.9	16.6	15.9	22 [c]				
7	[b] 1.0				23 [c]				
8	10.4	7.0	15.6	14.6	24	9.2	8.4	14.2	13.1
9	20.5	4.6	14.0	13.3	25 [a]				
10	18.3	4.6	12.0	11.4	26	28.3	4.7	13.0	12.4
11 [c]					27	5.3	8.4	16.0	14.6
12	13.1	13.0	14.4	12.7	28 [c]				
13	9.6	8.3	14.6	13.4	29	2.3	10.9	14.6	13.1
14	2.5	16.6	18.6	15.9	30 [c]				
15 [c]									
16	9.4	7.9	18.4	17.0	Average	10.9	8.6	15.4	14.1

[a] A small, shriveled beet. [b] Excluded from average. [c] No beet. [d] Data missing

These results are interesting from several points of view. In the first place the average of the analyses indicates the reliability of the original method of sampling as fairly representing the entire plat. Secondly, a great variation in individual samples is shown, suggesting the great care which is essential for securing a small number of beets to fairly represent the entire tract. It is evident that with careless work it would be possible to secure widely differing results as the 30 beets analyzed varied in sugar content from 11.4 to 17.7 per cent. Also, there is clearly shown the absolute necessity, in this climate at least, of calculating to the original weight where samples are kept for a few days before analysis.

The meteorological data from the Pomona Station show an average temperature of 67.7° F., including the months from March to September, which period represents the season in this locality. In this connection it must be taken into consideration that the principal growth of the beets occurs during the early part of the season. March, April, and May are comparable with May, June, and July for the nonirrigated regions. It is evident that it is the first three months of the growing season in which the temperature produces its principal effects. In this time the real character of the beet is formed and its habit of storing sugar fixed. It will be seen, therefore, that the mean temperature of March, April, and May, 61.30° F., was quite favorable to the development of a beet of the character given, namely, of 13.3 per cent of sugar. Further, it is noticed that irrigation was withdrawn in July, after which time the beet simply approached the condition of maturity. Thus, while June, July,

August, and September were very warm, it is probable that little if any growth took place after July.

The yield per acre is very fair and the sugar content good, but the purity is somewhat low, not reaching the minimum of 80, which is considered the lowest purity compatible with the economic production of sugar from the beet.

The individual analyses of 30 beets are of interest to show the wide variation which may occur in the content of sugar in beets grown in juxtaposition. These variations are often explained by the corresponding variation in the size of the beets, the small beets, if healthy, containing a larger percentage of sugar. The rapidity with which beets dry out in arid climates, such as that of California, is also illustrated by this statement.

THE COLORADO STATION.

The season of 1904 is reported as having been very favorable to the beet crop in northern Colorado. The sugar factory in the district of the experiment station reported an average tonnage of slightly less than 15 tons per acre from 6,400 acres. A number of large fields reported over 25 tons per acre.

The experimental plat at Fort Collins (Field F, plat 6) was weeded and thinned on May 31, and irrigated three times—on July 4, July 15, and August 2, respectively. The plat was harvested on October 22 and gave a yield of 16.86 tons of clean beets per acre, the tare being 8 per cent.

The agricultural and analytical data reported by Mr. A. H. Danielson, of the Colorado Station, are given in the following table. Of interest in connection with these data are the climatic conditions as shown in the table of meteorological data, a part of which was observed at Cheyenne, Wyo., 40 miles northeast of Fort Collins, being the nearest point at which sunshine observations were made.

Agricultural and analytical data determined at Fort Collins, Colo., on beets grown at that station, 1904.

Date of sampling.	Beets in 50 feet of row.		Average weight after topping.	Estimated yield per acre.	Sugar in juice.	Sugar in beet.	Purity coefficient.
	Number.	Total weight.					
		Pounds.	*Ounces.*	*Tons.*	*Per cent.*	*Per cent.*	
September 28[a]	.....	.....	12.8	.....	16.7	15.4	83.5
October 12	64	72.0	18.0	16.5	17.4	16.2	88.4
October 15	64	64.0	16.0	14.8	18.0	16.7	87.9
October 20[b]	.....	.....	16.0	.....	17.5	15.8	87.6
October 22	.....	69.8	21.4	16.0	18.0	16.4	89.1
Averages	64	68.6	16.8	15.8	17.5	16.1	87.3

[a] Determination made at Washington, D. C., on this date. [b] Average of 12 samples.

Meteorological data for Fort Collins, Colo., 1904.

Month.	Mean temperature.	Precipitation.	Sunshine.[a]			Clear days.[a]	Cloudy days.[a]
			Actual.	Possible.	Percentage.		
	° *F.*	*Inches.*	*Hours.*	*Hours.*	*Per cent.*		
May	53.7	5.37	[b] 110.7	[b] 213.5	[b] 52	5	11
June	59.9	1.68	248.1	451.9	55	8	12
July	65.6	1.99	316.1	458.6	69	17	5
Averages and totals	59.7	9.04	.....	.....	58	30	28
August	67.1	.71	279.1	427.4	65	9	6
September	59.2	1.09	265.7	374.0	71	11	7
October	48.9	.39	282.0	343.9	82	17	6
Averages and totals	58.4	2.19	.....	.....	73	37	19
General averages and sum totals	59.1	11.23	.....	.....	65	67	47

[a] Observations for Cheyenne, Wyo., 40 miles northeast of Fort Collins. [b] For 15 days only.

Mr. Danielson makes the following remarks on the irrigation practiced and its effect:

The amount of water applied at each irrigation has not been measured, but I judge that it would not exceed four-tenths of a foot per acre in the earlier irrigations, decreasing to about two-tenths of a foot per acre in depth in the later irrigations. The beets are always cultivated as soon as the ground is dry enough after each irrigation until the plants become too large to admit the passage of implements between the rows. It is usual also to use a shovel plow in the latter part of the season, making furrows at the same time.

I have repeatedly noticed a peculiar fact in connection with the irrigation of beets in this section, which has been corroborated by several expert sugar-beet men and may be stated briefly as follows: If beets under irrigation are kept supplied with water so that they do not become too dry at any time, and especially if water is applied toward the end of the season when the beet is maturing, it will mature earlier with a larger percentage of sugar and a larger tonnage than if the crop has suffered for water, especially during the latter part of the season; that is, sugar beets from which water has been withheld will continue green and growing until very late in the season; the beet will not mature well, and is often caught by the frost; nor will the sugar content be very high.

The agricultural data show that the beets from the Colorado Station were of good size, reaching an average of 16.8 ounces after topping.

The yield was good, namely, 15.8 tons per acre, and the content of sugar in the beet extremely high (16.1 per cent). The purity also was above the average, being represented by the coefficient 87.3. The meteorological data show the mean temperature from May to July to be 59.7° F., from August to October, 58.4°, from June to August, 64.2°, and for the entire season, 59.1°. The temperature in Colorado may be compared directly with the temperature data for the nonirrigated regions, as its growing season, unlike that of California, is coincident with that of nonirrigated stations. The low temperature, according to the general relation which has already been established, was highly favorable to the development of a beet rich in sugar. Even the warmest month, August, had a

temperature of only 67.1°. The rainfall was sufficient for the growth of the plant for the first three months, but was unevenly distributed. May had a precipitation of 5.37 inches, while the precipitation for June and July was less than 2 inches. August, September, and October were quite dry, and without irrigation the growth of the plants would have been prematurely checked. The data show that this section of Colorado is capable of producing not only a yield satisfactory to the farmer but also a crop which is exceedingly rich in sugar, with a high purity. Beets of this character, with proper treatment at the factory, should yield nearly 300 pounds of sugar per ton.

The following table is a comparison of the results obtained on the experimental plat No. 6, which had received no fertilization for two years, and those obtained on the adjoining plats which had been fertilized in 1903, as indicated, no part of the field (F) having received any fertilizer in 1904:

Comparison of fertilized and unfertilized plats, 1904.

No. of plat.	Fertilizer applied in 1903.	Yield per acre.	Tare.	Total weight of 12 samples.			Sugar in—		Purity coefficient
				Beets and leaves	Beets only.	Leaves.	Juice.	Beets.	
		Tons.	*Per ct.*	*Lbs.*	*Lbs.*	*Lbs.*	*Per ct.*	*Per ct.*	
5	Bone meal, 200 pounds per acre; nitrates, 150 pounds per acre	17.90	10.2	19.0	13.6	5.4	18.0	16.2	86.5
6	None	16.86	8.0	17.6	12.5	5.1	17.5	15.8	87.6
7	Bone meal, 200 pounds per acre	16.08	9.75	20.3	14.7	5.6	17.8	16.0	87.5

In commenting on the fertilizer experiments, Mr. Danielson writes as follows:

Our fertilizer experiments with sugar beets are still being continued and the results are not ready for publication; but I can summarize briefly the practical results of the work. Nitrogen in any form on our soils seems to be the most effective in increasing the tonnage. In commercial fertilizers the nitrogen from nitrates has been the most effective, raising the tonnage on nitrogen-poor ground from 10 tons to as much as 17 tons per acre, and from 20 to 24 and 25 tons per acre. Stable manure will also have practically the same effect with the additional benefit derived from the humus added to our humus-poor soils.

An excess of nitrogen on the sugar beets in my experiments has lowered the sugar content from one-half to one and one-half per cent, and the purity from 1 to 5 points. We found that a little available phosphorus in the form of acid rock, bone meal, or acid bone meal will tend to prevent this lowering of the sugar content and purity, and also seems to be very beneficial in giving hardiness to the young beet early in the season. Interesting facts have been observed in regard to the other elements of plant food experimented with, but these are the most practical points.

THE SOILS.

DESCRIPTIVE NOTES ON UNIRRIGATED SOILS.

Washington, D. C.—The beet plat on the Potomac flats at Washington was located very near that of 1902, the data being used as determined for that year. This soil, as previously stated, is an artificial deposit of material dredged from the bottom of the Potomac River.

Lafayette, Ind.—Soil samples were removed on April 29 from six places on the experimental plat, the surface soil to a depth of 9 inches and the subsoil 12 inches, i. e., from 9 to 21 inches. The history of this plat is as follows:

1881–1884.—Connecticut experiment on potatoes.
1885.—Wheat.
1886.—Oats.
1887.—Corn, heavily manured.
1888–1890.—Corn.
1891–1894.—Corn, heavily manured.
1895.—Kafir corn, fertilized with 92 pounds of bone, containing 34 per cent of phosphoric acid; 92 pounds of sodium nitrate, containing 16 per cent of nitrogen, and 46 pounds of muriate of potash, containing 50 per cent of potash.
1896.—Kafir corn, fertilized with 17 pounds of dissolved boneblack, containing 16 per cent of phosphoric acid; 6½ pounds of sodium nitrate, containing 16 per cent of nitrogen, and 75 pounds of muriate of potash, containing 50 per cent of potash—(K_2O).
1897.—Kafir corn.
1898–1899.—Clover.
1900.—Soy beans and cowpeas plowed under; sown to wheat October 11.
1901–1902.—Wheat.
1903.—Corn.
1904.—Beets.

Lexington, Ky.—The sugar beets having been grown on the same plat of loamy bluegrass soil as in the four previous years, the soil analyses were not repeated, but the data obtained in 1903 are inserted in the table for comparison.

Agricultural College, Mich.—The soils were sampled on October 28, air dried, and forwarded on November 15, with the following history of the plat from which they were taken, no fertilizer having been applied since 1890:

1890.—Wheat, yield 15 bushels per acre.
1891–1892.—Oats, yield 56 bushels per acre.
1893.—Wheat, yield 10 bushels per acre.
1894.—Oats, yield 25 bushels per acre.
1895.—Oats, yield poor.
1896.—Oats, yield 48 bushels per acre.
1897.—Oats, yield 40 bushels per acre.
1898.—Oats, yield small.
1899.—Fallow, sown to wheat (winter fife) in the fall.
1900.—Wheat, mostly winter killed.

1901.—Clover.
1902.—Oats, yield 50 bushels per acre.
1903.—Clover, yield 2 tons per acre.
1904.—Beets.

Ithaca, N. Y.—The soil on which these experiments were conducted is reported as being a sandy loam of good depth and fertility which was well limed and fertilized in 1904. Two samples of beets were sent, one from fresh land and one from the plat on which beets had been growing for four years. It is regretted that no new soil analyses were made, but the analysis of this soil made in 1902 is inserted in the table as a general indication of its character.

Geneva, N. Y.—The soil used was a clay loam, quite uniform throughout, and very much like that on which beets were grown in 1902, the plats being separated only by farm road. The data determined in 1902 are accordingly used in the table of soil analyses. This field has been used for farm crops in rotation ever since it came into the possession of the station and for the past five years the crops have been as follows: 1889, oats; 1890, wheat seeded to clover and timothy; 1891 and 1892, meadow; 1893, corn.

Statesville, N. C.—The beet plat was situated on a ridge, the soil being a rather dry clay loam, comparatively fresh. Corn was grown on the land in 1903, a crop of about 40 bushels to the acre being obtained.

Blacksburg, Va.—For several years the beets have been grown on various portions of the garden, a different plat being used each year. The plat selected in 1904 was grown last year in garden crops for an early harvest and then was planted to late Indian corn. The land was covered with manure in the fall of 1902 and had been so treated for several years previous, but no such application has been made since that date. The soil is a fairly rich loam, such as occurs on the bench land of this section just above the streams. The uplands here are not rich, but the rock is nearly always lime. This particular soil is drift, but it is not what is called bottom or muck lands.

Madison, Wis.—The soil is a clay loam, with a heavy clay subsoil, and has a decided tendency to bake after rains. A part of the field was in sugar beets in 1902 and in rape or pease in 1903. This field has been in cultivation for at least 30 years, and has been brought to a high state of fertility by the application of barnyard manure for the past 12 years or more.

DESCRIPTIVE NOTES ON IRRIGATED SOILS.

Pomona, Cal.—While the particular location of the plat for the work of 1904 was different from that selected in 1902 yet the soil characteristics were essentially the same with the exception that the subsoil was far less leachy, it having been found to be impossible

in the former location to supply the amount of moisture necessary to produce a reasonable tonnage. As to its general physical character the soil would be classed as sandy and its general chemical character, as determined at the California Station, is given in the report for 1902.[a] The analyses made at the Bureau of Chemistry of the samples sent in 1904 are given in the general table below.

Fort Collins, Colo.—This plat in 1904 was planted in beets for the second year without fertilizer and was sampled very near the same spot as in the preceding year. The plat was in grain in 1902 and in beets in 1901.

COMMENT ON ANALYSES OF SOILS.

The analytical data representing the composition of the soil are obtained by two methods of solution: (1) By using concentrated hydrochloric acid, in which practically all of the soil constituents soluble in acid are obtained; and (2) by using dilute hydrochloric acid, which solution represents the amounts of potassium and phosphoric acid which may be regarded as immediately available for the growth of the crop.

The following table shows the results of analyses of the soils used in the cooperative experiments in 1904:

Chemical analysis of sugar-beet soils, 1904.

[Percentages based on water-free soil.]

NONIRRIGATED SOILS.

Serial No.	Locality	Description.	Nitrogen.	Soluble in 1.115 HCl.				Soluble in N/200 HCl.	
				K_2O.	CaO.	MgO.	P_2O_5.	P_2O_5.	K_2O.
			Per ct.	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
3181	Statesville, N. C.	Soil	0.078	0.29	0.06	Trace.	0.04	0.0001	0.0088
3182	do	Subsoil	.063	.33	.02	Trace.	.04	.0001	.0080
24868[b]	Ithaca, N. Y.	Soil	.17	.21	.35	0.45	.18	.00207	.0114
24869[b]	do	Subsoil	.06	.66	2.00	.84	.09		
3126	Lafayette, Ind.	Soil	.224	.82	.33	.46	.11	.0018	.0086
3124	do	Subsoil	.161	.80	.29	.76	.08	.0001	.0043
2147[c]	Lexington, Ky.	Soil	.208	.50	.54	.38	.51		
2148[c]	do	Subsoil	.127	.29	.45	.21	.11		
25125[b]	Washington, D. C.	Soil	.18	.39	.47	.51	.08		
3133	Blacksburg, Va.	Soil	.141	.45	.09	.84	.11	.0002	.0124
3134	do	Subsoil	.050	.50	.12	.86	.04	.00015	.0076
3137	Agricultural College, Mich.	Soil	.109	.30	.32	.27	.05	.00015	.0038
3138	do	Subsoil	.091	.19	.54	.09	.04	.0006	.0096
1754[b]	S. & F.	Geneva, N. Y.	Soil	.17	.56	.56	.82	.09	.0001	.0087
1755[b]	S. & F.	do	Subsoil	.10	.89	.81	1.27	.06		
3129	Madison, Wis.	Soil	.195	.42	.64	.51	.12	.0011	.0043
3130	do	Subsoil	.087	.46	.43	.54	.11	.00055	.0024

IRRIGATED SOILS.

3121	Pomona, Cal.	Soil	0.040	0.08	1.66	5.62	0.19	0.0007	0.0098
3122	do	Subsoil	.042	.62	4.67	3.29	.10	.0001	.0011
3127	Fort Collins, Colo.	Soil	.70	.89	3.20	4.02	.11	.0002	.0029
3128	do	Subsoil	.115	.80	8.72	4.46	.11	.0005	.0089

[a] U. S. Dept. Agr., Bureau of Chemistry Bul. No. 78, p. 30.

[b] Analysis for 1902 samples.

[c] Analysis for 1903 samples.

Considering the nonirrigated soils in respect of the content of nitrogen, the richest are those from Lexington, Ky., and Lafayette, Ind., while the soils from Ithaca, Blacksburg, Agricultural College, Geneva, and Madison form a group having a moderate amount of nitrogen and differing only slightly from each other in this respect. The soils at the other stations are not so well provided with nitrogen, having only about half as much as the soils of the stations in the first group. In every case there is less nitrogen in the subsoil than in the soil, as is to be expected.

In regard to the potassium soluble in strong hydrochloric acid, it is seen that the soil having the largest quantity is from Indiana and the soil having the smallest quantity is from Ithaca. In several cases the subsoil is found to contain more potassium than the soil, and this is notably true in the case of Ithaca, Lafayette, Blacksburg, and Geneva. In regard to the phosphoric acid soluble in the strong acid, the largest quantity is found in the sample from Lexington, and the smallest (always excluding that from Statesville, N. C.), from the Michigan Station. In regard to the lime, the largest quantity is found in the soil from Wisconsin and the smallest quantity in the sample from Blacksburg, Va. In one instance there is more lime in the subsoil than in the soil, in the case of Ithaca, where the same relation is observed in the case of potassium.

It is to be noticed that there is found a much larger proportion of lime in the irrigated soils than is usually found in the nonirrigated areas, with the exception of the lime in the subsoil at Ithaca. All the soils and subsoils of the irrigated stations show large quantities of carbonate of lime. This is especially true of the soil from Fort Collins, which approaches in texture the chalky soils of parts of England. The large amount of lime in the Fort Collins soil shows that there must have been originally large quantities of lime present, for Fort Collins is not situated in a very dry climate, the data showing that it received almost as much rain as some of the nonirrigated stations during the growing season.

In the following table is given a comparison of the yields at the various stations and the average amounts of plant foods in the soils and subsoils. Attention may again be called to the fact that it is not possible to correlate these factors with scientific exactness, such a comparison only being possible for purposes of making conclusive deductions when the soils are subjected to the same environment, as was the case in the pot experiments conducted during a series of years by this Bureau.

Yield of beets and soil data, 1904.

[Average of figures for soil and subsoil.]

NONIRRIGATED SOILS.

Station.	Yield of beets.	Nitrogen.	Soluble in 1 115 HCl.		Soluble in N 200 HCl.	
			Potash.	Phosphoric acid.	Potash.	Phosphoric acid.
	Tons.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Statesville, N. C.	1.5	0.072	0.31	0.04	0.0089	0.0001
Ithaca, N. Y.	7.6	.12	.44	.14	.0114	.00107
Lafayette, Ind.	8.3	.193	.71	.10	.0065	.0009
Lexington, Ky.	8.9	.183	.40	.31		
Blacksburg, Va.	13.3	.095	.48	.08	.0090	.0009
Washington, D. C.[a]	14.9	.18	.39	.03		
Agricultural College, Mich.	15.2	.13	.25	.05	.0067	.0001
Geneva, N. Y.	19.0	.135	.725	.09	.0087	.0001
Madison, Wis.	19.9	.14	.44	.12	.0034	.00071
IRRIGATED SOILS.						
Pomona, Cal.	10.5	0.041	0.66	0.10	0.0055	0.0046
Fort Collins, Colo.	15.8	.142	.89	.11	.0109	.0004

[a] Soil only.

The data, however, show in a general way what has been observed before, that the quality of the soil has but little to do with the sugar content of the beet. It is true that if the soil be so very poor that the beet is very much stunted in its growth, reaching a weight of only 2 or 3 ounces at maturity, the poverty of the soil would act in this way to increase the percentage of sugar in the beet, but this is only incidental since any unfavorable condition would act in the same way, as, for instance, a deficient rainfall or imperfect cultivation. It is quite certain that a very rich soil, in the presence of an environment otherwise favorable to a large growth, would have the opposite effect, for the overgrown beet is prone to have an excess of cellular tissue, to become pithy, and be less sweet. In this case, also, the effect is largely fortuitous, for it is evident that in any condition of overfertility the beets may be grown so close together as to prevent large size, and thus their percentage of sugar may be largely conserved.

It is undoubtedly true that the use of certain fertilizers in definite proportions may tend to increase the percentage of sugar. This is particularly true of potash and phosphoric acid. On the contrary, an abundant supply of nitrogenous fertilizer may tend to depress the content of sugar. In the latter case the effect is probably due to a tendency to increase the growth, while in the former case it may be partly due to securing a proper ripening of the beet, and thus avoiding overgrowth, and partly to actual saccharigenic influences of the fertilizers themselves. Whatever the physiological action may be, it is evident that neither soil nor fertilizer is the dominant or even an important factor affecting the percentage of sugar in the beet.

During the course of the five-year investigation no attempt has been made to study specifically the effect of fertilizers upon the sugar content of the beet, but incidentally it has been borne in mind. Such special studies have, however, been made by others and a brief outline of the results obtained is appended. The conclusion drawn by MM. Hébert and Charabot is entirely in harmony with the deductions made in the incidental study of the subject during this investigation.

In a somewhat elaborate study entitled "The influence of the nature of the environment upon the organic composition of the plant," by these investigators, appearing in the Bulletin de la Société Chimique de Paris[a] the following conclusions are drawn from the summary of the analytical results obtained:

1. Vegetable assimilation, at least up to a certain limit, remains almost invariable in proportion to the growth; the relative organic composition at the end and at the beginning of the vegetation is found to be almost the same, with a reservation in regard to nitrogen.

2. The assimilation in the plants belonging to the several groups is similar from the organic point of view as it is from the mineral standpoint; the fertilizers or the salts added did not modify sensibly the relative composition of the plant. The substances added act in an absolute (nonrelative) manner, whether it be in diminishing the vegetable production if they are harmful, or in increasing it if they are helpful.

This conclusion is very important as regards the use of fertilizers which are thus seen to act only on the production of vegetable matter without modifying sensibly its composition.

An abstract of the results obtained by K. Andrlík[b] is as follows:

In experiments with phosphoric acid alone Mr. Andrlík found that with small additions a small increase in sugar content was secured. Large applications of phosphoric acid, no matter in what form, whether as superphosphate, basic slag, or mineral phosphate, also acted favorably, both in increasing the yield and the sugar content of the beet. These larger amounts, however, did not increase either the quantity or the quality of the beet proportionately to the amounts added.

Moderate quantities of nitrogen in the form of Chile saltpeter had a diminishing effect upon the sugar content of the beet, and it was found that the quantity of soda in the roots was twice as great as where no Chile saltpeter had been employed. The conclusion was therefore reached that Chile saltpeter when used alone, even in moderately small quantities, exerts an unfavorable influence upon the sugar content of the beet. Moderate quantities of chlorid of potassium or sulphate of potassium produced favorable results upon the sugar content of the beet but did not increase the tonnage per acre. Larger quantities of potash fertilizers, however, did increase the yield as well as the sugar content in a marked degree. The influence of the sulphate of potassium was somewhat more marked than that of the chlorid. The combination of Chile saltpeter and superphosphate acted favorably upon the beets in producing a larger tonnage but did not change the sugar content. Where very large quantities of this mixed fertilizer were used the ash content of the beet was markedly increased so as to interfere with its proper manufacture, but the sugar content was not diminished. Potash and phosphoric acid combined in moderate quantities increase both the yield per acre and the sugar content and to a much greater extent than when used singly.

The combination of three fertilizing elements, viz, chlorid of potash, superphosphate, and Chile saltpeter, had a very marked effect not only in increasing the crop, but especially in increasing the sugar content. The combination of these three plant foods in moderate

[a] Third series, volume 29–30, No. 24, December 20, 1903, p. 1239.

[b] Zeit. des Ver. der deut. Zuc.-Ind., September, 1903, p. 948.

quantities shows itself to be extremely favorable. Also quite as favorable results were obtained by a combination in which the superphosphate was replaced by an equivalent amount of basic slag except that the quality of the beet in this combination was not quite so good. Equally favorable results were obtained by replacing the superphosphate or basic slag by mineral phosphate. It was also noticed particularly that in the combination of the three elements each one of them was much more readily utilized by the plant than when they were used separately. With very intensive fertilization, using chlorid of potash, Chile saltpeter, and phosphoric acid, the yield was very markedly increased, but the quality of the beet deteriorated by reason of the presence of an excess of salts.

SUMMARY OF DATA.[a]

The following is a summary of the data secured in the experiments of 1904:

Agricultural and analytical data, 1904.

WHERE IRRIGATION WAS NOT USED.

Station.	Mean weight of topped beets.	Estimated yield per acre.	Sugar in beet.	Coefficient of purity.
	Ounces.	*Tons.*	*Per cent.*	
Washington, D. C	12.5	14.9	11.4	76.1
Lexington, Ky	9.8	8.9	11.5	72.4
Ithaca, N. Y	6.0	7.6	12.4	76.2
Madison, Wis	14.4	19.9	12.9	82.2
Geneva, N. Y.[a]	14.4	19.0	13.7	83.7
Blacksburg, Va	9.8	13.3	13.8	81.2
Statesville, N. C.[b]	6.6	1.5	14.5	81.3
Lafayette, Ind	8.3	8.3	15.1	85.8
Agricultural College, Mich	9.9	15.2	15.5	86.0

WHERE IRRIGATION WAS PRACTICED.

Pomona, Cal	10.9	10.5	13.3	78.6
Fort Collins, Colo	16.8	15.8	16.1	87.3

[a] Data determined at the station.
[b] Data not platted nor discussed under general conclusions.

Meteorological data, May to October, 1904.

WHERE IRRIGATION WAS NOT USED.

Station.	Temperature.	Precipitation.	Clear days.	Cloudy.	Sunshine.
	°*F.*	*Inches*			*Per cent.*
Washington, D. C	67.3	19.1	79	36	62.0
Lexington, Ky	68.4	13.0	94	24	73.0
Ithaca, N. Y	61.6	16.7	56	63	.....
Madison, Wis	62.0	22.0	61	59	.....
Geneva, N. Y	62.8	21.0	[a] 89	[a] 45	61.5
Blacksburg, Va	63.6	18.3	19	41	.....
Statesville, N. C	68.8	19.2	62	28	[b] 61.0
Lafayette, Ind	65.3	18.7	62	93	66.0
Agricultural College, Mich	61.5	14.4	[c] 52	[c] 63	[c] 59.0

WHERE IRRIGATION WAS PRACTICED.

Pomona, Cal.[d]	67.7	6.7	181	31	77.5
Fort Collins, Colo	59.1	11.2	[e] 67	[e] 47	[e] 65.0

[a] Data for Lyons, N. Y.
[b] Determined for Asheville, N. C.
[c] Data for Detroit, Mich.
[d] Data from March to September.
[e] Determined for Cheyenne, Wyo.

[a] For geodetic data see five-year summary, p. 48.

CONCLUSIONS DRAWN FROM RESULTS OF EXPERIMENTS IN 1904.

The average data, agricultural, analytical, meteorological, and geodetic, for the year 1904, as collected in the tables of summaries and platted on the graphic charts, show the following relations:

In regard to the size of beets harvested, it is noticed that the results at only two of the stations fulfilled the requirements of profitable beet culture from the farmer's point of view. These are the stations at Madison, Wis., and Geneva, N. Y., where the weight of the beets after topping was almost a pound. The smallest beets reported from the stations which appear in the graphic charts were from Ithaca. The size of the beets at this station, as well as that of the beets from Lexington, Blacksburg, Lafayette, and Agricultural College, was greatly below the required standard. The beets from Washington occupy a mean position between these extremes, having a weight of 12.5 ounces.

The stations at Madison, Geneva, Agricultural College, and at Washington represent what should be considered typical yields, varying from 19.9 to 14.9 tons. It is evident that, from the farmer's point of view especially, the principal effort should be devoted to securing yields of approximately the magnitude mentioned. The yield at Blacksburg of 13.3 tons is fairly satisfactory and would be a profitable crop if the other conditions were favorable, while the tonnages at Lexington, Ithaca, and Lafayette are below the limit of profitable agriculture.

Respecting the sugar in the beet, four groups of the stations presented on the graphic charts may be made (disregarding decimals), the first including Michigan and Indiana, with 15 per cent; the second including Geneva and Blacksburg, with 13 per cent; the third including Ithaca and Madison, with 12 per cent; and the fourth including Lexington and Washington, with 11 per cent. It is evident that all the beets analyzed might prove profitable for sugar making in so far as the sugar content is concerned.

Respecting purity, two groups may be made, the beets from Madison, Geneva, Blacksburg, Lafayette, and Agricultural College constituting the first group, having a purity of over 81, Lafayette and Agricultural College showing the highest, while the beets from the other stations, Washington, Lexington, and Ithaca, form a group having a purity ranging from 72 to 76. This low purity, combined as it is with a correspondingly lower content of sugar, would render the manufacture of sugar from these beets less profitable.

A comparison of the beets from the two irrigated stations shows the great superiority of the beets grown at the Colorado Station, which is doubtless to be largely attributed to the low temperature at that station.

A comparison of the meteorological data is also interesting. The highest mean temperature from May to October is found at Lexington, 68.4° F., and the lowest mean temperature at the Michigan Station, 61.5°, with Ithaca only one-tenth degree higher. The stations may be placed in two groups in respect of temperature, the first of which would include Washington, Lexington, and Lafayette, with the higher temperature, and the second the other collaborating stations. In respect of rainfall the heaviest precipitation occurred at the Wisconsin Station, amounting to 22 inches, and the smallest at Lexington, namely, 13 inches. In regard to the number of clear days the highest number is found at Lexington and the lowest at Blacksburg. The largest number of cloudy days was reported from Lafayette and the smallest from Lexington. The percentage of sunshine could not be obtained from all the stations, but as reported the highest percentage was at Lexington and the lowest at the Michigan Station.

At the two irrigated stations a striking difference in mean temperature is noticed, Pomona having by 8.6° a higher temperature than Fort Collins for their respective growing seasons. In regard to the precipitation it is seen that Fort Collins can hardly be called purely an irrigated section, since the precipitation was almost as great as that at Lexington. Pomona has almost three times as many clear days as Fort Collins, and the percentage of sunshine also at the California Station was 12.5 per cent higher than that used for Fort Collins.

In regard to the geodetic data[a] the stations having the longest days are Madison and Geneva, each with a day of 14 hours and 44 minutes. Close to these are Agricultural College, Mich., where the average day has 14 hours and 42 minutes, and Ithaca, with 14 hours and 41 minutes. The shortest day is at Blacksburg, 14 hours and 14 minutes, and next to this is Lexington, with 14 hours and 18 minutes. The greatest altitude is found at Blacksburg, 2,100 feet, and the lowest at Washington, 37.5 feet. At the irrigated stations a marked difference is noted in altitude, Fort Collins having almost 5,000 feet, while Pomona has only 861, another disadvantage of the California Station. The interrelations of these various factors and their influence upon the sugar content of the beet are more clearly set forth in the graphic charts.

In chart No. 1 are graphically represented the percentage of sugar in the beet at the various stations, the percentage of sunshine, the number of clear days in the month, and the latitude of the station. In regard to the percentage of sugar in the beet, the chart shows that for the first time the Geneva Station does not hold the first place. Attention has already been called to the remarkable differ-

[a] See page 48.

ence in the percentage of sugar in the expressed juice of the beets grown at Geneva and the percentage of sugar in the beet itself. Had

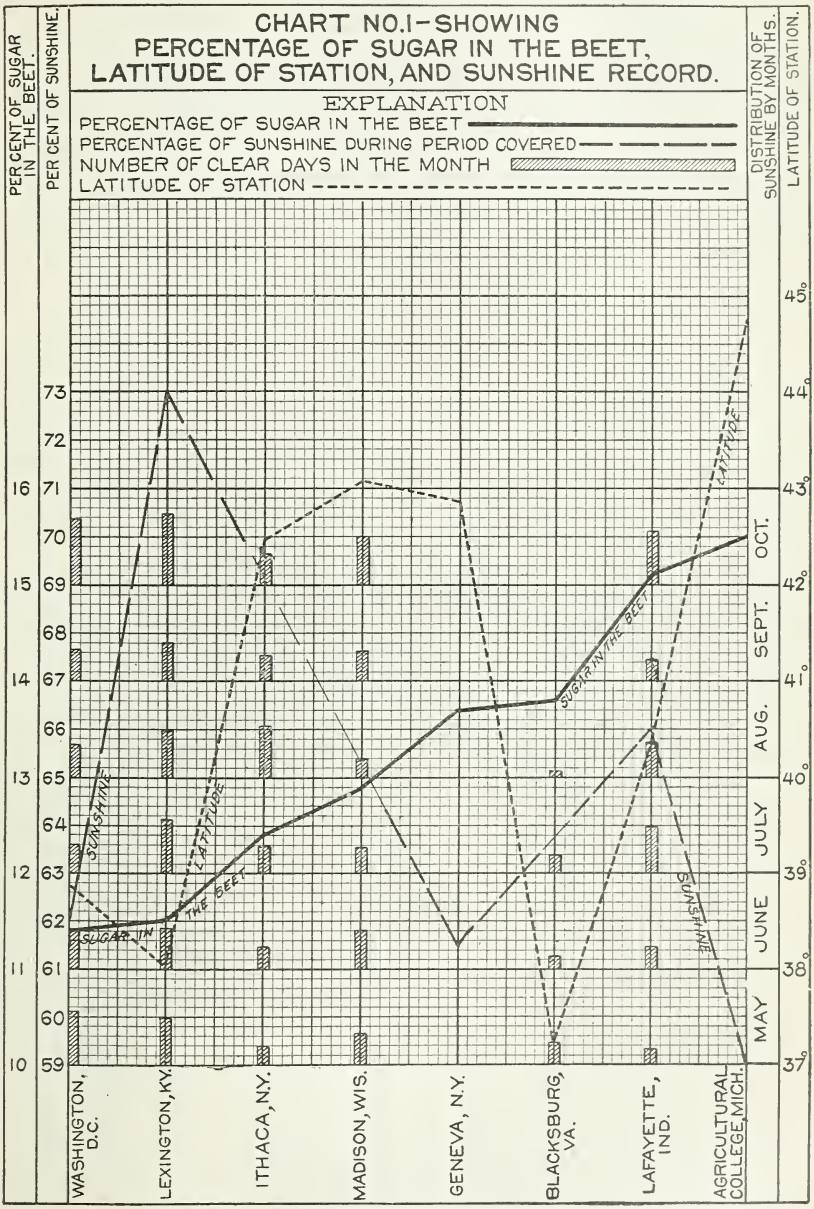

FIG. 1.—Sugar content of the beet as influenced by the amount and distribution of sunshine and the latitude of the station, 1904.

the calculations been made upon the basis of the percentage of the sugar in the juice, the Geneva Station would have retained its

position. The curve is remarkable in this respect, that it indicates a higher content of sugar at such stations as Washington and Lexington, which in former years have shown a percentage of sugar of less than 10. Although the percentage of sugar is higher than

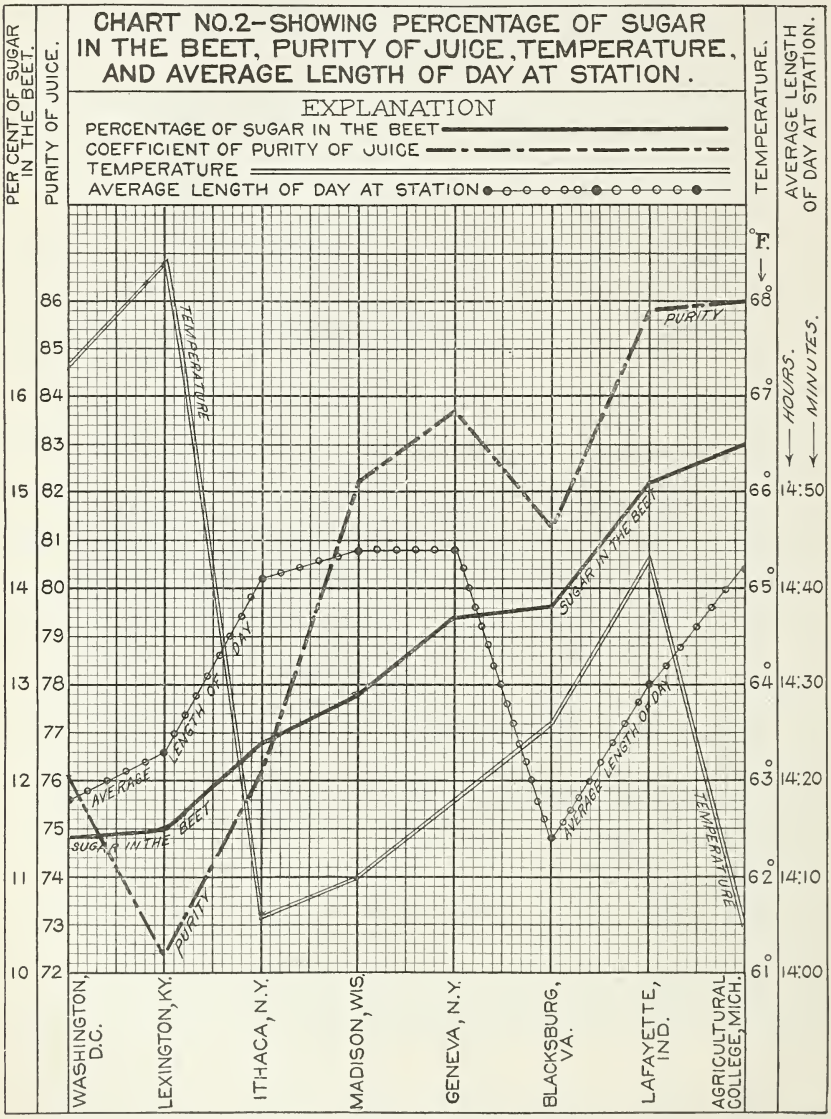

FIG. 2.—Sugar content of the beet compared with the purity and the temperature and average length of day at the various stations, 1904.

in other years, these two stations retain their positions in the two lowest places. The line representing the latitude follows in general the sugar content, with the exception of the station at Blacksburg. This variation, due to the altitude of the station, while it interferes

with the symmetry of the curve, is nevertheless extremely interesting from the point of view of these investigations. It is evident that the influence of latitude has two components, namely, length of day and degree of temperature. The curve for Blacksburg indicates that, of these two components, the one representing the degree of temperature is by far the more important. There seems to be but little relation shown in these investigations between the hours of sunshine and the sugar content. In this respect the data for the present year are entirely in harmony with those of previous years.

In chart No. 2 are found graphically represented the percentage of sugar in the beet, the coefficient of purity in the juice, the temperature, and the average length of day. In this chart we find that two sets of the graphically illustrated data coincide in general in their magnitude and direction with the content of sugar, namely, the purity of the juice and the average length of day. In regard to the latter point there is again a noted variation in the case of Blacksburg, which has the shortest day of all the stations under observation. This fact is again illustrative and interesting, since it shows that it is not alone the hours of sunshine, or rather the hours of daylight, which form the dominant factor in the production of sugar. There is no doubt at all that there is a tendency to diminish the content of sugar by diminishing the hours of daylight. The greatest difference in the length of day between Blacksburg with the shortest day, and Madison and Geneva with the longest day, is 30 minutes. Yet the richness in sugar of the beet at Blacksburg was greater than that at either of the two stations mentioned. This illustrates the fact that of the two components in the factor of the long day—namely, duration of the light and temperature—the latter is the more important. The temperature curve illustrates that the percentage of sugar is in inverse ratio to the elevation of the temperature; that is, in general, the higher the temperature the lower the content of sugar, and vice versa. For the present year this curve is not at all regular. There is an especial variation from it in the case of Lafayette, but if we take the two extreme points of Lexington and Agricultural College and connect them with a straight line, the general tendency of the factor above mentioned will be illustrated. The line which represents the sugar content of the beets of the various stations and the line which represents the average temperature at the same stations tend to form a figure like that of the letter X when platted graphically.

In chart No. 3 are platted the percentage of sugar in the beet, the total amount and monthly distribution of rainfall, and the altitude of the station. In this chart there is evidently but little relation between the lines representing the factors of environment and the sugar content. The Blacksburg Station again introduces a great irregularity, since its altitude is so much greater than that of any other station.

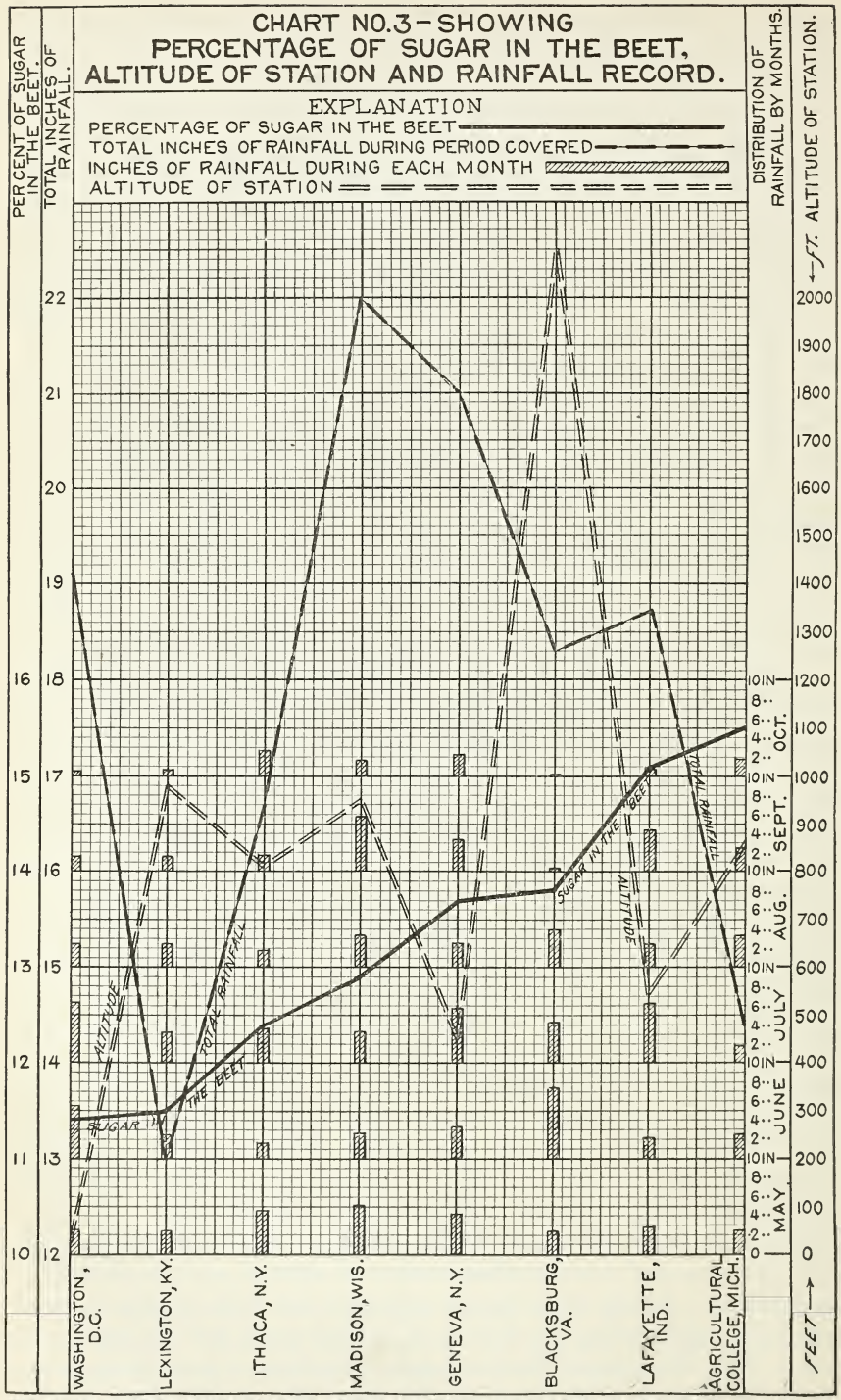

FIG. 3.—Sugar content of the beet as influenced by the amount and distribution of the rainfall and the altitude of the station, 1904.

The one really valuable lesson conveyed by this chart lies in showing that a high altitude may offset a low latitude in its relation to the content of sugar; this is shown in a remarkable manner in the case of the Blacksburg Station. It is perfectly evident from the data which have been collected and arranged that if the Blacksburg Station could be reduced to practically sea level, the character of the beets produced would be lower than that of the beets at Washington and Lexington, thus well illustrating the fact that the most depressing effects on the sugar content are produced by the combination of low latitude and low altitude. This is proved by the data obtained at Washington. The most satisfactory influences for the production of a beet rich in sugar are secured by the combination of a high latitude and a high altitude. There is an apparent exception to this in the case of the stations at Ithaca and Geneva. Ithaca is considerably higher than Geneva and only 26′ farther south, resulting in a lower temperature, and yet the beets grown at Ithaca have been uniformly inferior to those produced at Geneva. This relation is further discussed under the summary of the five years' work.

SUMMARY OF FIVE-YEAR EXPERIMENT.

Having discussed in previous reports[a] and in the foregoing pages of the present report the individual data collected at the different cooperating stations during the years 1900 to 1904, inclusive, it remains to bring these individual data together for comparison, in order to determine the average potency of each of the factors in the environment, and to this end the average figures for the five years are collected in tabular form and also expressed graphically, as has been done for each individual year. In the tables following are given the annual averages of agricultural, analytical, and meteorological data for the five years, and also in the general tables these averages for the five years as a whole, and the geodetic data as well:

DETAILED ANNUAL SUMMARIES OF DATA, 1900–1904.

Agricultural and analytical data for stations where irrigation was not used.

Place and year.	Estimated yield per acre.	Sugar in beet.	Coefficient of purity.
Lexington, Ky.:	*Tons.*	*Per cent.*	
1900	10.0	7.8	69.5
1901	8.0	9.0	71.0
1902	8.9	7.3	70.9
1903	6.3	9.5	72.0
1904	8.9	11.5	72.4
Averages	8.4	9.0	71.2
Washington, D. C.:			
1900	15.0	8.3	69.1
1901	8.1	8.5	67.3
1902	26.1	8.4	72.4
1903	14.6	8.7	71.6
1904	14.9	11.4	76.1
Averages	15.7	9.1	71.3
Blacksburg, Va.:			
1900	.....	.....	.....
1901	10.0	13.1	77.6
1902	16.7	11.7	74.4
1903	.....	.....	.....
1904	13.3	13.8	81.2
Averages	13.3	12.9	77.7
Madison, Wis.:			
1900	9.0	15.2	86.2
1901	11.0	12.7	77.4
1902	31.8	12.7	82.0
1903	19.5	11.6	79.0
1904	19.9	12.9	82.2
Averages	18.2	13.0	81.4
Lafayette, Ind.:			
1900	.....	9.9	83.0
1901	5.4	14.6	82.5
1902	.....	.....	.....
1903	8.9	13.2	81.6
1904	8.3	15.1	85.8
Averages	7.5	13.2	83.2
Ithaca, N. Y.:	*Tons.*	*Per cent.*	
1900	15.0	14.0	81.9
1901	12.6	14.6	79.9
1902	18.0	12.5	81.9
1903	13.4	12.2	75.0
1904	7.6	12.4	76.2
Averages	13.3	13.2	79.0
Ames, Iowa:			
1900	.....	11.7	76.9
1901	12.9	14.1	80.2
1902	.....	.....	.....
1903	15.6	15.5	81.8
1904	.....	.....	.....
Averages	14.2	13.8	79.6
Agricultural College, Mich.:			
1900	15.8	13.1	80.0
1901	10.2	14.6	81.5
1902	12.5	13.5	86.9
1903	.....	.....	.....
1904	15.2	15.5	86.0
Averages	13.4	14.2	83.6
Geneva, N. Y.:			
1900	.....	15.5	83.9
1901	13.8	15.8	83.9
1902	16.1	13.9	84.5
1903	15.6	14.2	89.4
1904	19.0	13.7	83.7
Averages	16.1	14.6	85.1

[a] U. S. Dept. of Agr., Bureau of Chemistry Buls. 64, 74, 78, and 95.

Agricultural and analytical data for stations where irrigation was practiced.

Place and year.	Estimated yield per acre.	Sugar in beet.	Coefficient of purity.
Logan, Utah:	*Tons.*	*Per cent.*	
1900	18.9	12.1	84.2
1901	23.4	14.2	79.1
1902	14.4	13.4	80.4
1903			
1904			
Averages	18.9	13.2	81.2
Pomona, Cal.:			
1902	5.0	15.0	86.5
1903			
1904	10.5	13.3	78.6
Averages	8.0	14.2	82.5
Fort Collins, Colo.:	*Tons.*	*Per cent.*	
1902	24.0	13.0	79.4
1903	21.5	15.1	85.0
1904	15.8	16.1	87.3
Averages	20.4	14.7	83.9

Meteorological data for stations where irrigation was not used.

Place and year.	Mean temperature.		Precipitation.	Clear days.	Sunshine.
	June, July, and August.	Six months.			
Lexington, Ky.:	°F.	°F.	*Inches.*		*Per cent.*
1900	76.3	72.1	16.90	100	75.9
1901	76.1	69.3	16.23	95	75.0
1902	77.3	69.3	16.60	83	76.1
1903	72.9	68.8	11.50	80	62.0
1904	73.3	68.4	13.00	94	73.0
Averages	75.2	69.6	14.85	90	71.6
Washington, D. C.:					
1900	76.8	69.0	19.34	81	64.0
1901	76.1	71.7	24.50	96	64.5
1902	73.8	68.6	23.50	80	67.0
1903	71.6	67.2	21.26	81	57.0
1904	72.6	67.3	19.10	79	62.0
Averages	74.2	68.8	21.54	83	62.9
Blacksburg, Va.:					
1900					
1901	70.1	63.8	32.08	79	53.7
1902	70.7	65.8	15.20	74	
1903					
1904	68.9	63.6	18.30	19	
Averages	69.9	64.4	21.86	57	53.7
Madison, Wis.:					
1900	71.0	66.4	16.30		
1901	73.9	65.6	14.33	48	
1902	67.1	60.5	27.40	55	58.0
1903	67.0	62.0	25.58	61	
1904	67.3	62.0	22.00	61	
Averages	69.3	63.3	21.12	56	58.0
Lafayette, Ind.:					
1900	74.3	69.8	30.5	64	64.7
1901	76.5	68.6	16.4	74	69.9
1902	71.1				
1903	69.4	65.9	17.4	82	58.0
1904	70.7	65.3	18.7	62	66.0
Averages	72.4	67.4	20.75	71	64.7

Meteorological data for stations where irrigation was not used—Continued.

Place and year.	Mean temperature. June, July, and August.	Mean temperature. Six months.	Precipitation.	Clear days.	Sunshine.
Ithaca, N. Y.:	°F.	°F.	*Inches.*		*Per cent.*
1900	70.4	65.1	13.8	50	69.2
1901	70.5	63.4	17.4	49	66.0
1902	65.9	60.4	23.3	41	.....
1903	63.9	60.2	22.7	42	46.0
1904	67.8	61.6	16.7	56	.....
Averages	67.7	62.1	18.8	48	60.4
Ames, Iowa:					
1900	73.1	68.2	36.30	89	62.7
1901	76.8	67.9	16.15	127	69.9
1902	.....	.....	.....	.....	.....
1903	69.2	63.6	22.43	105	60.0
1904	.....	.....	.....	.....	.....
Averages	73.0	66.6	24.96	107	64.2
Agricultural College, Mich.:					
1900	69.4	64.5	17.50	81	59.2
1901	70.2	62.8	19.84	96	61.8
1902	65.5	60.5	27.40	55	58.0
1903	.....	.....	.....	.....	.....
1904	66.9	61.5	14.40	52	59.0
Averages	68.0	62.3	19.79	63	59.6
Geneva, N. Y.:					
1900	71.4	66.0	15.00	.....	.....
1901	72.2	65.5	18.03	.....	.....
1902	68.1	63.1	20.20	.....	.....
1903	66.0	62.6	25.60	.....	.....
1904	68.7	62.8	21.00	89	61.5
Averages	69.3	64.0	19.97	.....	.....

Meteorological data for stations at which irrigation was practiced.

Place and year.	Mean temperature. June, July, and August.	Mean temperature. Six months.	Precipitation.	Clear days.	Sunshine.
Logan, Utah:	°F.	°F.	*Inches.*		*Per cent.*
1900	70.2	63.0	6.2	138	81.2
1901	70.3	64.0	7.37	130	76.3
1902	68.1	60.3	4.2	116	78.5
1903	.....	.....	.....	.....	.....
1904	.....	.....	.....	.....	.....
Averages	69.5	62.4	5.9	126	78.7
Pomona, Cal.:					
1902	70.2	70.0	.59	67	70.0
1903	.....	.....	.....	.....	.....
1904[a]	70.7	67.7	6.7	181	77.5
Averages	70.5	68.9	3.65	124	73.8
Fort Collins, Colo.:					
1902	66.1	60.0	14.8	94	62.5
1903	65.1	59.0	7.1	.....	.....
1904	64.2	59.1	11.2	67	65.0
Averages	65.1	59.4	11.0	80	63.8

[a] Data for March to September.

GENERAL SUMMARIES OF DATA, 1900–1904.

Table of general averages of agricultural and analytical data for the five years, 1900–1904.

STATIONS WHERE IRRIGATION WAS NOT USED.

Station.	Estimated yield per acre.	Sugar in the beet.	Purity coefficient.	Average temperature.	
				June to August.	May to October.
	Tons.	*Per cent.*		°*F.*	°*F.*
Lexington, Ky	8.4	9.0	71.2	75.2	69.6
Washington, D. C	15.7	9.1	71.3	74.2	68.9
Blacksburg, Va.[a]	13.3	12.9	77.7	69.9	64.4
Madison, Wis	18.2	13.0	81.4	69.3	63.3
Lafayette, Ind.[b]	7.5	13.2	83.2	72.4	67.4
Ithaca, N. Y	13.3	13.2	79.0	67.7	62.1
Ames, Iowa[a]	14.2	13.8	79.6	73.0	66.6
Agricultural College, Mich.[b]	13.4	14.2	83.6	68.0	62.3
Geneva, N. Y	16.1	14.6	85.1	69.3	64.0
STATIONS WHERE IRRIGATION WAS PRACTICED.					
Logan, Utah[a]	18.9	13.2	81.2	69.5	62.4
Pomona, Cal.[c]	8.0	14.2	82.5	70.5	[d] 68.9
Fort Collins, Colo.[a]	20.4	14.7	83.9	65.1	59.4

[a] Data for 3 years.
[b] Data for 4 years.
[c] Data for 2 years.
[d] 1904 data for March to September.

General averages of meteorological data (May to October) for the five years, 1900–1904.

STATIONS WHERE IRRIGATION WAS NOT USED.

Station.	Temperature.	Precipitation.	Clear days.	Sunshine.
	°*F.*	*Inches.*		*Per cent.*
Lexington, Ky	69.6	14.9	90	71.6
Washington, D. C	68.8	21.5	83	62.9
Blacksburg, Va	64.4	21.9	57	53.7
Madison, Wis	63.3	21.1	56	.....
Lafayette, Ind	67.4	20.8	71	64.7
Ithaca, N. Y	62.1	18.8	48	60.4
Ames, Iowa	66.6	25.0	107	64.2
Agricultural College, Mich	62.3	19.8	63	59.6
Geneva, N. Y	64.0	20.0	.....	.....
STATIONS WHERE IRRIGATION WAS PRACTICED.				
Logan, Utah[a]	62.4	5.90	126	78.7
Pomona, Cal.[b]	68.9	3.65	124	73.8
Fort Collins, Colo.[a]	59.4	11.00	80	63.8

[a] Three years' data.
[b] Two years' data; 1904 data for March to September.

Summary of geodetic data.

STATIONS WHERE IRRIGATION WAS NOT USED.

Station.	Average length of day.	Latitude.	Altitude.
	h. m.	° ′ ″	*Feet.*
Lexington, Ky	14 18	38 02 25	979.0
Washington, D. C	14 23	38 53 23	37.5
Blacksburg, Va	14 14	37 14 00	2,100.0
Madison, Wis	14 44	43 04 36	955.0
Lafayette, Ind	14 30	40 23 00	542.0
Ithaca, N. Y	14 41	42 27 00	810.0
Ames, Iowa	14 38	42 02 00	917.0
Agricultural College, Mich	14 42	44 45 00	847.0
Geneva, N. Y	14 44	42 53 00	453.0

STATIONS WHERE IRRIGATION WAS PRACTICED.

Logan, Utah	14 37	41 44 00	4,506.0
Pomona, Cal	13 58	34 03 00	861.0
Fort Collins, Colo	14 32	40 35 00	4,994.0

DISCUSSION OF FIVE-YEAR AVERAGES.

TONNAGE.

It is not advisable to discuss each of the tables of the summary separately, as the purpose of the investigation will be realized by the study of the table of averages. The agricultural data show some very curious results. It is seen that in the five years the yields per acre at Washington, Blacksburg, Madison, Ithaca, Ames, Agricultural College, and Geneva are fairly satisfactory, being in each case over 12 tons. Two of the stations, namely, Lexington and Lafayette, show a yield of approximately half a crop only, and Raleigh, from which only two years' data were obtained, shows practically a complete failure of the crop, and is therefore excluded from the summary. Moreover, it must be remembered that the tonnage figures have been estimated in all cases upon the weights of beets from very small areas, and thus it is evident that these results may not be strictly accurate. It is, nevertheless, true that these data show with a considerable degree of accuracy the comparative yields at the various stations.

The practical failure of the crop at Raleigh appears to have been due more to the uneven distribution of the rainfall than to any other source, in so far as the meteorological data throw any light upon the subject. In so far as the possibility of producing a large crop is concerned, there is no reason to believe that the station at Raleigh would necessarily occupy such an inferior position.

PERCENTAGE OF SUGAR IN THE BEET.

These are by far the most important of the agricultural data collected, since the special object of the investigation was to consider the effect of the environment upon the content of sugar alone, and not

upon the general composition of the beet. The stations are arranged in the table of general averages in accordance with the percentage of sugar, the lowest being placed first. First, attention should be called to the well-known fact that a phenomenally small yield or small-sized beets tends to increase in an abnormal way the percentage of sugar in the beet. The beet being a plant which by long continued selection and cultivation has formed a habit of producing sugar, tends to exercise that habit even under the most adverse circumstances. The habit of sugar forming, therefore, may be said to be a ruling passion in the beet, strong even in poverty, and the actual storage room of the small beet being limited, it is only natural to find it more fully stocked with the sugar produced. This point must be fully considered in comparing the sugar content of the beets produced at Lexington and Lafayette with those from the other stations. It is perfectly reasonable to suppose that had the crops at these stations been normal the percentage of sugar would have been greatly reduced. Any slight displacement, therefore, in the natural order in which the stations would have appeared (considering temperature and sugar content) does not in any way interfere with the general proposition which has been established throughout this long series of observations, viz, that temperature, or, in other words, latitude, is the most potent element of the environment in the production of a beet rich in sugar.

Again, Geneva, which not only produced the largest crop next to Madison, but also the richest beets, should, under normal conditions, have occupied the position held in the table by Ithaca, considering their relative temperatures and altitudes, but not their latitudes. Although Geneva is about 35 miles farther north, by reason of its lower altitude the average temperature for the five years is higher at Geneva than at Ithaca. Many modifying circumstances, which influence to a greater or less degree the effect of the temperature upon sugar production, have been active in the general problem, and are discussed under the following caption. These modifications, however, are of so slight a nature as not to decrease the value of the general conclusions.

TEMPERATURE.

NONIRRIGATED SECTIONS.

The average temperature is given in the general table, both for the whole period of six months and for the three most important growing months—June, July, and August. There is a very marked relation between the average temperature and the sugar content of the beet, although, as has already been mentioned, there are some variations from the general rule, the several factors of the environment interacting on each other so as to modify these general relations. It is seen

that, although Lexington is farther south than Washington, and thus would naturally have a considerably higher temperature, it is about 942 feet higher, and this altitude has a tendency to diminish the temperature. It must be remembered, however, that Washington, by reason of its propinquity to the sea, has a climate which is modified to a greater or less extent by the influence of the ocean, whereas Lexington has practically an intracontinental climate, being removed from all bodies of water, not even having the modifying influences of a river. This accident of situation is one of the circumstances explaining the slightly higher temperature of the Lexington station, and the fact that only half a crop was produced also tends to place the beets grown at Lexington in the relation to the Washington crop that theory would predict, despite the slight difference in percentage of sugar in the beet of one-tenth per cent in favor of the Washington crop.

The most conspicuous departure from the general rule is shown in the data from Ithaca. The mean temperature at Ithaca is less than at any other of the collaborating stations, being 0.2° F. less than at Agricultural College, Mich., and 1.9° less than at Geneva, only 35 miles north. The inferiority of the beets grown at Ithaca is due to some cause which does not clearly appear in the agricultural and meteorological data. Numerous modifying conditions may, however, be suggested. The inferior size of the beet grown at Ithaca, the small crop, and the markedly low purity are to be kept in mind, as well as the inferiority in sugar content. The comments of Mr. J. W. Gilmore, of the Ithaca Station, made in response to a letter from the Bureau of Chemistry calling attention to the peculiar relations apparently existing between the beets grown at Ithaca and at Geneva, are of general interest and are submitted in part as follows:

> Your letter of recent date regarding the factors which influence the quality of sugar beets here in Ithaca has been received and I have given the matter considerable attention, inasmuch as I have been much interested in the points which you bring out. I have observed for some time that better sugar beets were grown north of us, both at the north end of Cayuga Lake and also between Cayuga and Seneca lakes in the vicinity of Geneva, than in the vicinity of Ithaca. I refer both to the sugar content and purity as well as to the tonnage. While I have never studied this matter in detail, yet I believe the following factors are influential in bringing about such conditions:
>
> In the first place, the soil at the north end of Cayuga Lake and in the vicinity of Geneva seems to be better adapted physically for sugar beets than it is here. Several years ago, when the Binghamton sugar factory was in operation, a number of contracts for sugar beets were let in this locality and they proved to be practically unprofitable, while the beets have been grown for the factory successfully in the neighborhood of Union Springs and farther north. I think the physical condition of the soil of this locality and north of us is quite an important factor in the development of better beets in the vicinity of Geneva.
>
> In the second place, I believe there is more sunshine during the growing season in the vicinity of Geneva than there is here in Ithaca. The lack of sunshine here is very noticeable throughout the entire year, but especially in the winter time. It may be, too, that Geneva is far enough north to enable them to have sunshine during a longer daylight period while the beets are growing than at Ithaca.

Thirdly, I think the frequency of rainfall in the two localities is different. There may not be much difference between the total rainfall at the two points, but I think there is some difference, which might have a considerable influence upon the development of the sugar beet, in the frequency of showers in the two localities.

It would, of course, require a special research to discover what part the soil, either physically or chemically considered, played in this problem. The mechanical analyses of the soils and subsoils at Ithaca and Geneva, made by the Bureau of Soils, are given on page 38 of Bulletin No. 78, report of 1902.

It has been several times mentioned that the lack of sunshine data for Geneva was much regretted, but these observations were not obtainable for any point near enough to be of value. The suggestions made as to the effect of sunshine, length of day (Geneva having a day three minutes longer), and distribution of rainfall might work together to explain, at least in a measure, the inferiority of the Ithaca beets, in accordance with the theories developed by the observations and results at other stations, although no relation between sugar content and sunshine data has been established.

IRRIGATED SECTIONS.

These data are at best only preliminary, since they do not cover the whole period of the investigation. The experience of the last twenty years has shown the probability of a very wide extension of the sugar-beet industry on irrigated lands. The desirability of such an extension rests upon an economic basis. In the first place, the control by irrigation of the distribution of water renders the production of a crop practically certain. The other meteorological data are usually of such a constant nature as not to endanger the production of an average crop. The predominating factor, therefore, in so far as yield is concerned, is the distribution of the water. Thus it happens that the crop of beets that will be harvested in the arid regions may be confidently predicted within a few tons. Such a prediction renders all of the farm operations connected with the production of the crop more certain and more economical. In the second place, it is highly important to secure for irrigated areas a crop which shall have a high money value per acre with a reasonable margin of profit. The cost of bringing lands under irrigation as a rule is considerably greater than that of preparing land in the nonirrigated regions for cultivation. The actual cost, therefore, of the land, other things being equal, is greater in the irrigated than in the nonirrigated areas. This higher cost fastens upon the farmer a fixed charge which must always be provided for in the crop before a margin of profit is possible. The ordinary average crops do not always present the most hopeful avenue of securing this increase of profit. For instance, the amount of Indian corn or other cereals or grass crops, with the possible exception of

alfalfa or other species of clover, does not afford the opportunity of certainly discharging the obligation accruing from the interest on the investment in land. The sugar beet, however, adds further inducements in this direction because of the possible and even certain production of an average crop of not less than 15 tons per acre, having a money value delivered at the factory of from $60 to $75. These ideas are fully borne out by the data from the Utah and Colorado stations. The average yield at Logan is 18.9 tons per acre and at Fort Collins 20.4 tons. The average content of sugar in the beet is quite satisfactory at both places, being very good at Fort Collins. The purities are reasonably high, and the data collectively indicate a probable value at the factory of not less than $5 a ton. The yield at the Pomona (Cal.) Station indicates only half a crop, but the quality of the beets as shown by the data is satisfactory.

At all three of the stations where irrigation was employed the average temperature for the growing season is favorable to the production of beets high in sugar. Pomona, with the highest temperature (68.9° F.), being 1.1° below the maximum mean temperature of 70°. It is interesting to compare these stations with Geneva, N. Y., in this respect. The average temperature at Geneva for the six growing months is 64°; at Logan, 62.4°, and at Fort Collins, 59.4°. For the three principal growing months—June, July, and August—the average temperature at Geneva is 69.3°; at Logan, 69.5°, and at Fort Collins, 65.1°. The temperature at Fort Collins is uniformly lower than at the other stations, owing, as is readily seen, largely to its high altitude.

PURITY.

It has been the general observation during this investigation that the purity coefficient always increases with the sugar content of the beet. This general relation is shown very plainly in the tables. Lexington, with the lowest content of sugar, shows the lowest purity, and Geneva, with the highest content of sugar, shows the highest purity. There are, however, irregularities in the curve representing these data, but these variations only serve to accentuate the general principle illustrated by the data.

PRECIPITATION.

NONIRRIGATED SECTIONS.

A study of the precipitation data for the six growing months shows a close agreement between the nonirrigated stations. The greatest average precipitation during the period observed was at Ames, Iowa, 25 inches. The smallest rainfall is recorded for Lexington, Ky., viz, 14.9 inches. This amount of rainfall is so small as to plainly indicate the chief cause of the small crop produced at that station. At all the

other stations it is seen that the average rainfall is about 20 inches, showing a remarkable uniformity with the exception of Ames and Lexington. The full value of these data can only be determined by studying the distribution of the rainfall in the various annual reports of this investigation. It is evident at once from a study of this kind that the total amount of precipitation for the six months is really greater than the crop required if it could have been distributed evenly and at the proper times. This of course is not possible when dependence is placed upon natural causes alone. In the detailed records discussed in previous bulletins it has been clearly pointed out that the rainfall does not directly, but only incidentally, affect the sugar content of the beet. The great function of the rainfall is related to the magnitude of the crop. Incidentally the rainfall affects the sugar content of the beet in the following way: If the distribution of the rainfall or its deficiency is such as to produce a very small crop made up of small or undersized beets, it exerts the incidental tendency of increasing the percentage of sugar in the beet. A very abundant and well-distributed rainfall by supplying the conditions to grow a beet of extraordinary size will have the opposite effect, of diminishing the percentage of sugar in the beet. If after a period of dry weather during which the beets have matured, as shown by the change in color and the falling of the leaves, there comes a period of warm, wet weather, a second growth will be induced in the beets during which to a certain extent the stored sugar is consumed, with the incidental result that the percentage of sugar in the beet will be diminished. The total changes in percentage composition induced by the rainfall may reach considerable magnitude and may determine whether or not in the process of manufacture favorable economic results will be obtained. Far more important than this effect, however, are the relations of the rainfall to the magnitude of the crop—relations which are well established but which do not form an essential part of this investigation.

IRRIGATED SECTIONS.

The inspection of the table of average precipitation shows that the Fort Collins Station approaches in its average rainfall that of Lexington, Ky., which had the least precipitation of any of the nonirrigated stations. The average precipitation for the six months at Fort Collins is 11 inches, while the average precipitation of Lexington is 14.9 inches. The average precipitation at Logan, Utah, for the six growing months for three years is 5.9 inches. The station at Pomona, Cal., may be regarded as actually arid, since the average precipitation for two years is only 3.7 inches, making it evident that the natural precipitation at this station is a wholly unimportant factor.

CLEAR DAYS AND SUNSHINE.

In the detailed records representing the work of the different years attention has been called to the fact that the active principle of light, in so far as it affects the sugar content of the beet, is not probably the most luminous element. It is apparent, at least to a certain extent, that the diffused light from a cloudy sky has practically the same effect in producing sugar as the direct sunlight. The study of the environment, therefore, in respect of the number of clear days and the hours of sunshine does not show as close a relation to the production of sugar as was expected before the investigation was begun. Of the nonirrigated stations the one showing the largest average number of clear days during the five years is Ames, Iowa, while Ithaca represents the other extreme. Of the irrigated stations Logan shows the largest number of clear days and Fort Collins the smallest.

In respect of percentage of sunshine at the nonirrigated stations the highest figure occurs at Lexington, viz, 71.6 per cent, and the lowest at Blacksburg, 53.7 per cent. At the irrigated stations the highest percentage of sunshine is found at Logan and the lowest at Fort Collins. It is evident, therefore, from a study of these average data, that it is not possible in the present state of our knowledge to find any direct relation between the content of sugar in the beet and the number of clear days and percentage of sunshine.

COMPOSITION OF SOIL AND YIELD PER ACRE.

The data appearing in the accompanying table show that Lafayette, Ind., had the smallest yield and Madison, Wis., the largest yield during the series of four years. The crop both at Lafayette and Lexington must be regarded as abnormally small. The yield at the other stations is satisfactory. It was not the purpose of the present investigation to study the soil as a factor of the environment affecting the yield, but only as affecting the sugar content. It is evident that there is only one method by which such a study could prove of value, viz, the establishment of the experiment under conditions which would eliminate all the varying factors with the exception of the composition of the soils themselves. This ideal method of studying the effect of soil on sugar content is to bring the soils, in sufficient quantity, from the different stations to one station, thus eliminating all disturbing factors of the environment save those due to soil alone. This test was included in the original scheme for these studies, but opportunity to carry it into effect was not presented. Inasmuch as in all instances the distribution of the rainfall has been shown to be one of the dominant factors in determining yield, it is hardly necessary to continue further any comparison of the soil and yield data which were merely incidental to the principal purposes of the investigation.

Summary of yield and soil data for four years, 1901–1904.

Station.	Yield per acre.	Nitrogen.	Soluble in 1.115 HCl.		Soluble in N/200 HCl.	
			Potash.	Phosphoric acid.	Potash.[a]	Phosphoric acid.[a]
	Tons.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Lafayette, Ind.[b]	7.5	0.224	0.48	0.10	0.0069	0.00053
Lexington, Ky.[b]	8.0	[a].187	[a].30	[a].47	.....	.....
Ithaca, N. Y	12.9	[b].144	[b].37	[b].14	[c].0077	[c].00003
Blacksburg, Va.[b]	13.3	.149	.54	.10	.0144	.00005
Agricultural College, Mich.[b]	14.3	.118	.21	.06	.0052	.00036
Washington, D. C	15.2	[b].165	[b].35	.05	[c].0062	[c].00020
Geneva, N. Y.[b]	16.1	[a].125	[a].63	[a].09	.....	.....
Madison, Wis	20.5	.132	.35	.11	.0037	.00056

[a] Average for two years.
[b] Averages for three years except where otherwise noted.
[c] Data for one year.

The data show that any direct effect that soils may have upon the sugar content is that which has already been alluded to in sufficient detail, viz, the soil diminishes the sugar content when there is a tendency to produce an overgrowth due to an excess of plant food, and has a corresponding tendency to increase to a slight extent the sugar in the beet where the amount of plant food is not sufficient to produce a normal growth.

The study of the use of fertilizers and manures in the growth of beets and the effect on the sugar content naturally would be considered in connection with the study of the effect of the soil. Such a use of manures, including what are known as commercial fertilizers, as would produce an extraordinary tonnage would tend to diminish the percentage of sugar in the beet. In addition to this it has been shown that certain kinds of fertilizers and manures are more effective in this direction than others. This is especially true of the nitrogenous fertilizers, both when used in the form of nitric acid and also in organic compounds. This class of fertilizers tends preeminently to produce increased tonnage, to develop abundant leaf and root growth, and as a result to diminish to a slight extent the percentage of sugar in the beet while greatly increasing the tonnage. On the other hand, phosphoric acid, and to a less extent potash, show a tendency to bring the beet to an early maturity, thus checking undue growth and increasing to a slight extent the percentage of sugar in the beet. When, however, we consider the total yield of sugar per acre rather than the actual percentage of sugar in the beet, it is evident that that system of manuring which would produce a very much larger crop will cause an almost corresponding increase in the total sugar produced per acre. The general conclusion from the study of these experiments and similar ones made by other investigators is that the soil and, to a somewhat less extent, the fertilizers and manures have only a limited influence upon the actual content of sugar in the beet, and that influence is incidental rather to the vigor of growth than to any specific action on the sugar content itself.

GRAPHIC REPRESENTATIONS OF DATA FOR FIVE YEARS.

It remains now to consider in the aggregate the graphic representations of the average data collected during the five years' study of this problem. First in this connection will be presented the charts showing graphically the aggregate data in the same order as that in which they were presented in the charts for each year.

Chart No. 4 includes the graphic illustration of the percentage of sugar in the beet, the percentage of sunshine, and the latitude of the station. The stations are arranged in the order of the sweetness of the beets produced. Lexington, Ky., occupies the lowest position in this chart and Geneva, N. Y., the highest. The lines present irregularities and no attempt was made to select certain stations to secure a straight line. The curve representing the latitude in general lies in the same direction as that of the sugar content. In fact, if each of these lines were reduced to a straight line by computation, they would lie almost parallel. The chart shows but little relation between the percentage of sunshine and the sugar content of the beet; in fact, the curve of sunshine is highest at the Lexington station, which is the lowest in sugar content. If only a part of this curve were studied, beginning with the Blacksburg Station, there would be less disagreement between the sunshine curve and the sugar content, but such a study is entirely inadmissible, as it would indicate the utilization of selected data in harmony with a certain theory and the exclusion of data not in harmony therewith. In order to present more clearly the relations of the two principal lines in this chart a special graphic illustration has been made (chart No. 7), including only the five stations which were compared throughout the whole five years of the study. These lines are superimposed as closely as possible in such a way as to transect each other proportionately. This method of illustration presents more clearly the existing relations.

In chart No. 5 a graphic illustration has been made of the average data for five years on the sugar content, purity, temperature, and length of day. Considering first the temperature, it is seen that, although there are extreme variations in some instances, there is nevertheless a distinct and marked relation between the temperature and the sugar content. As the temperature rises the content of sugar falls. The important exception to this rule is shown by the curve for Lafayette. The causes which produced so rich a beet at Lafayette have already been sufficiently discussed and account in a great measure for the variation. It is evident, moreover, that in so complicated a problem as the environment presents for a period of five years it was quite impossible to get a correct solution of all the equations between the different factors. In other words, there are

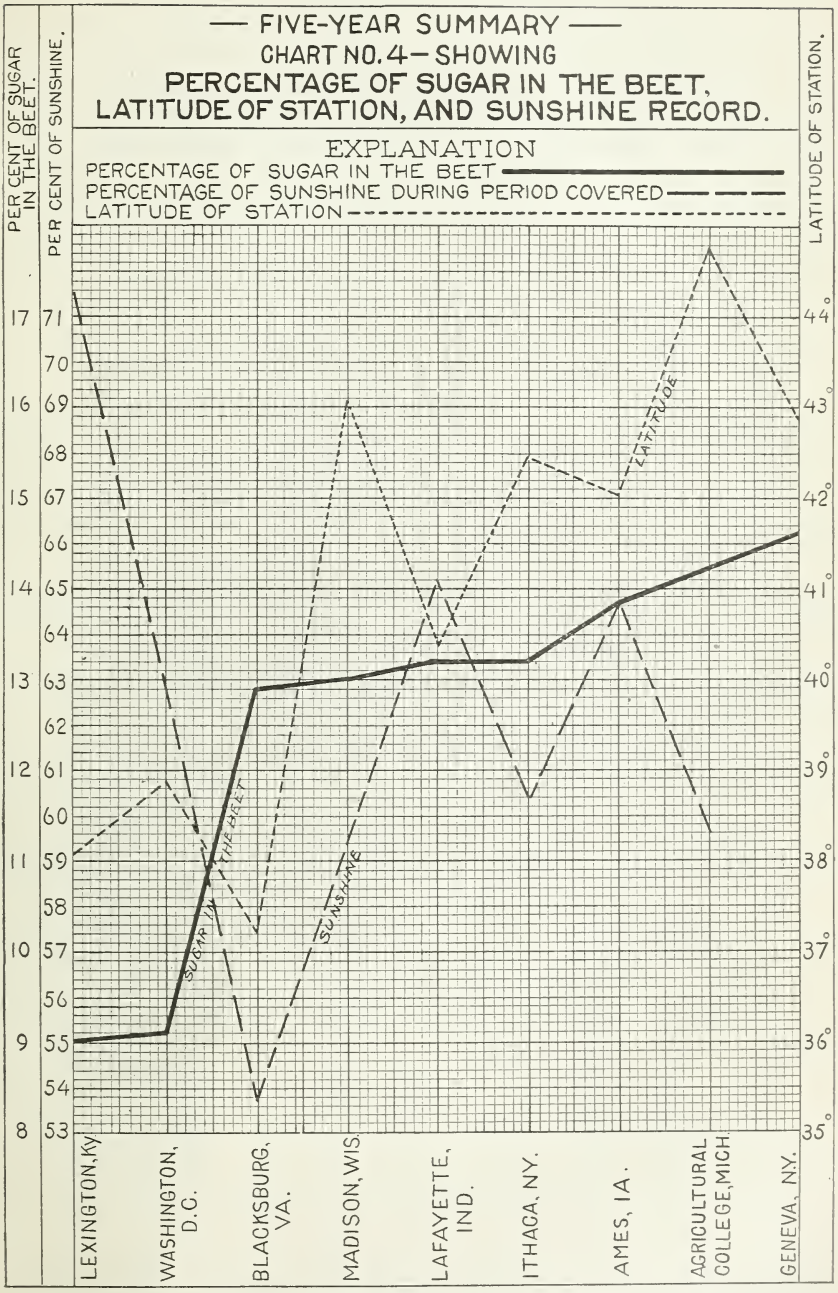

FIG. 4.—Sugar content of the beet compared with the latitude and sunshine record for five years.

more unknown quantities than there are equations with which to determine them. The curve for the length of day shows a very close correspondence, as shown by the graphic chart, to that for the con-

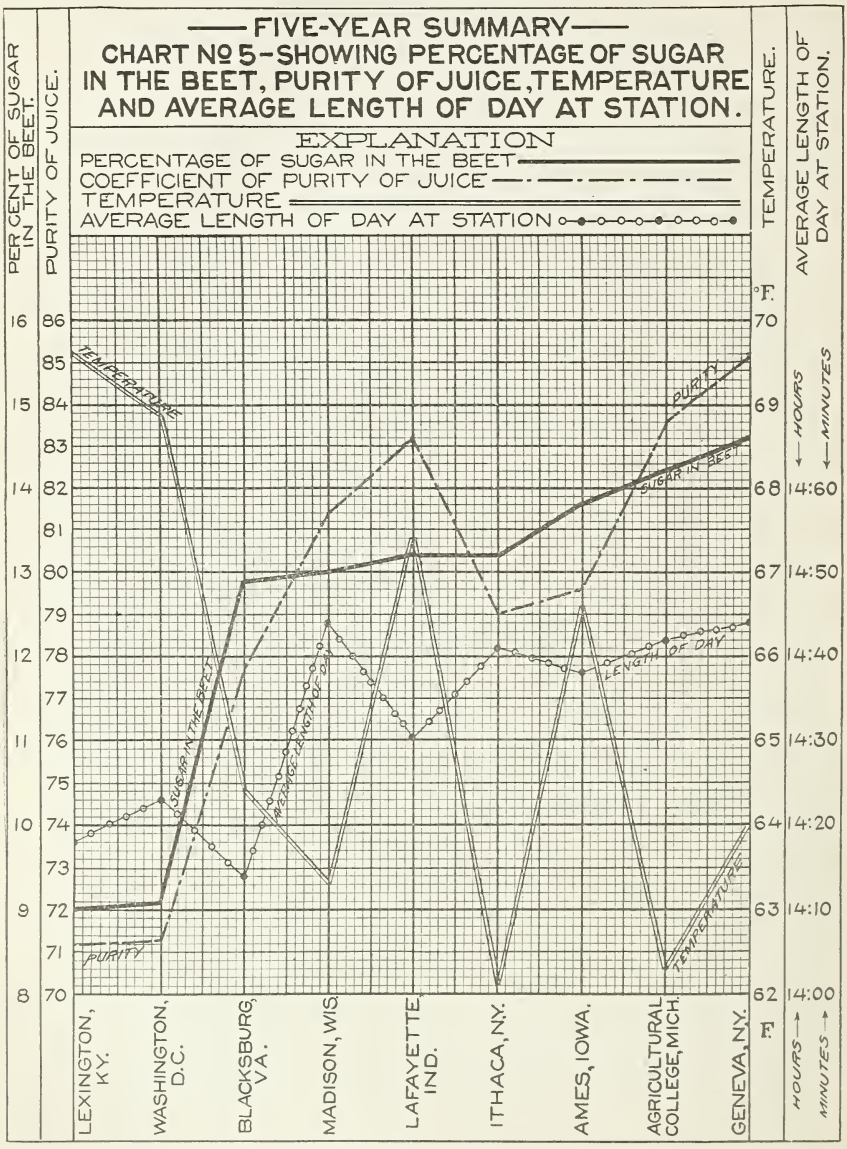

FIG. 5.—Sugar content of the beet compared with the purity of the juice, temperature, and average length of day for five years.

tent of sugar; since the length of day is only a function of the latitude there should be a very close agreement between the two curves. This agreement, however, is displaced by the injection of the factor

FIG. 6.—Sugar content of the beet compared with the rainfall, and altitude of station for five years.

of altitude into the problem. The altitude affects very materially the sugar content but does not affect the length of day. Any variation, therefore, between these two curves can be very properly accredited to the altitude. By this method of study it may be possible to trace more accurately than could be done otherwise the influence of the altitude upon the sugar content.

The line indicating the purity of the juice for the five years shows in a most convincing manner the effect of the sugar content upon purity; as the sugar content rises the purity increases. This relation is shown more vividly in chart No. 10, where only the sugar content and purity curves for the five stations for the five years are platted.

Chart No. 6 shows the average data for the period of five years on the sugar in the beet, the total rainfall, and the altitude of the station. There is an apparent relationship shown between the sugar content and the total rainfall, but it must be admitted that such a relation is largely fortuitous. The distribution of the rainfall, unfortunately, could not well be graphically illustrated for the five years, and inasmuch as the distribution is quite as important as the total amount of rainfall the two should be considered together for the purpose of reaching any valuable conclusion. The most instructive feature of chart No. 6 is illustrated by the tendency which the high altitude has manifested in compensating for the low latitude in the effect upon the sugar content. To a great degree this is shown in the results at the Blacksburg Station, where an altitude of over 2,100 feet was sufficient to counteract the natural depressing effect of the latitude of the locality, bringing the sugar content of the beet at Blacksburg almost up to a mean position in the whole series. To a minor degree this influence is also shown at Lexington, where the high temperature, higher than that of Washington, combined with a high altitude, higher than that of any other station with the exception of Blacksburg, has tended to raise the sugar content of the beet so that it is only one-tenth of 1 per cent below that at Washington. At the Lexington Station, however, it must not be forgotten that there was another factor, viz, the small size of the beets, which tended to increase the percentage of sugar.

In order to bring the gene al results for the five stations completing the five years work into a more striking comparison, graphic charts have been constructed in which each of the three most important elements of the environment affecting composition is represented separately, and a fourth graphic chart has been added showing only the relations existing between the purity and sugar content. These charts (Nos. 7 to 10) are constructed on the following principles.

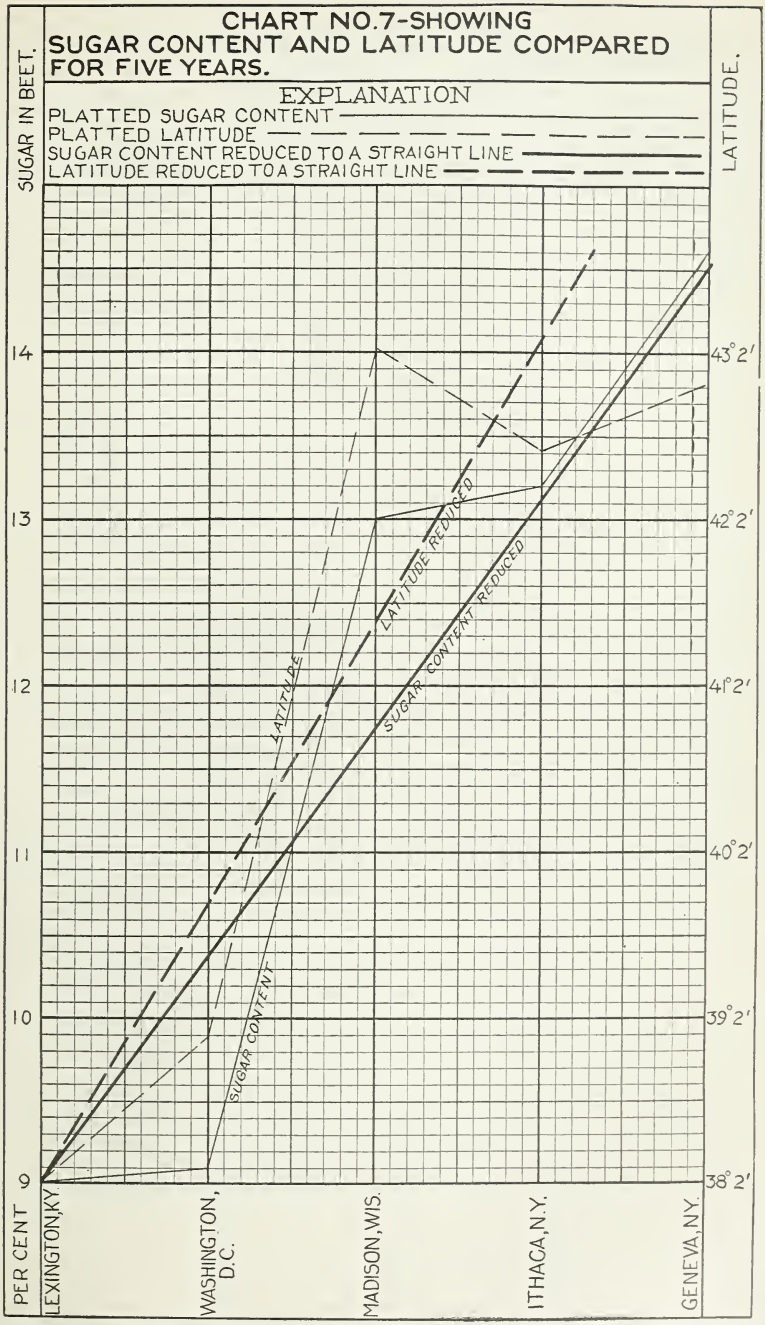

FIG. 7.—Comparison of sugar content and latitude for the five stations completing the entire five years of the experiment.

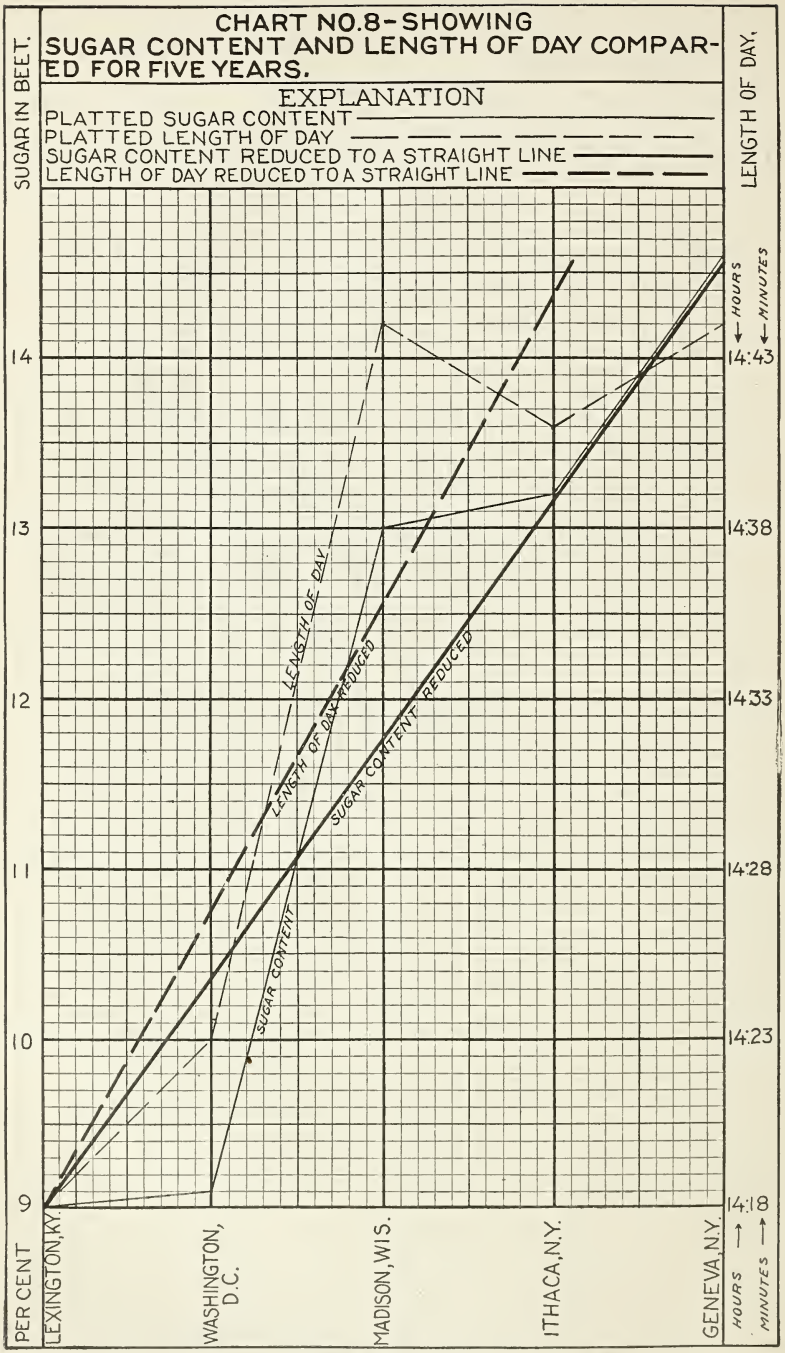

FIG. 8.—Comparison of sugar content and length of day for the five stations completing the entire five years of the experiment.

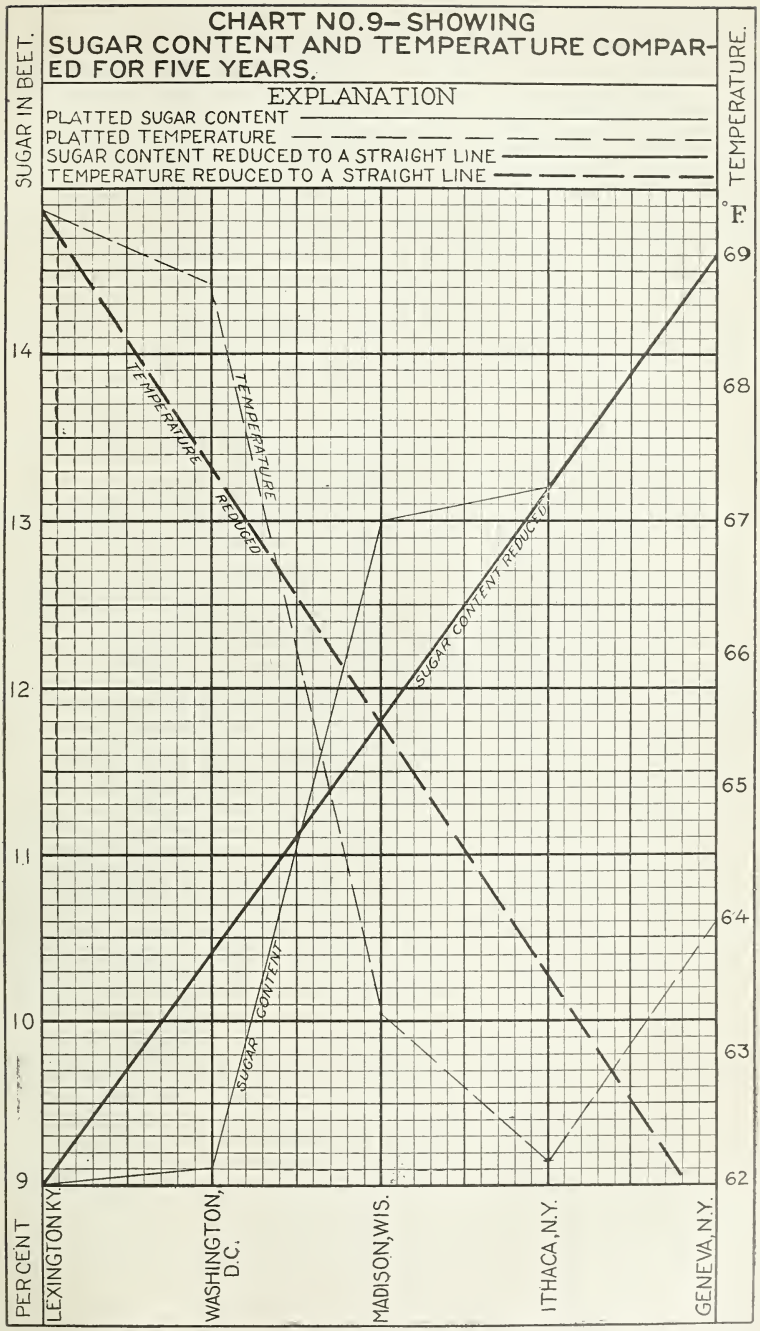

FIG. 9.—Comparison of sugar content and temperature for the five stations completing the entire five years of the experiment.

The basic curve in each of the four charts is the content of sugar at the different stations, which are arranged in order of sugar content. For the purpose of securing a better comparison this curve is reduced to a straight line. The straight line is so placed as to represent as nearly as possible the mean variations of the curve. In other words, an attempt is made to represent in a straight line the total change in the sugar content at the five stations on the supposition that the magnitude of the change was the same for each successive station. On each of the charts there is platted in order one of the four other factors already alluded to, viz, latitude, length of day, temperature, and purity. In each case, however, the curve is platted according to the data collected and the straight line is drawn representing the mean value of the curve. While, of course, it is almost impossible, without the use of elaborate calculations, to exactly place a line of this character, the straight lines on the charts represent approximately the mean values of the curves.

It becomes easy to distinguish at once the general relation which exists between the sugar content and the factor of the environment represented in each case by the straight line drawn as above described. Any detailed description of these final graphic charts is unnecessary, as a glance at the st aight lines of each chart shows the intimate relations existing between the sugar content and the other factors mentioned. In the case of latitude and length of day, the two straight lines having the same origin diverge only slightly from that representing sugar content, and the straight lines for purity and sugar content run still more closely together. The platted and the computed lines for sugar content coincide on Charts 9 and 10 between the points representing Ithaca and Geneva. In the chart representing the relation of the temperature to sugar content it is seen that the straight lines make almost a perfect X. These final graphic charts represent, therefore, in the simplest form of expression, the relations which have been established by the studies conducted throughout a period of five years.

We have now reached the end of this long and laborious research, and while there are many points in connection with the influence of environment which are not clearly brought out, it is believed that the major factors have been determined with considerable accuracy in regard to their influence on the composition of the beet.

The great extent of our country affords exceptional facilities for studying the effect of environment in widely separated localities. In former studies by this Bureau the chemical composition of cereals[a]

[a] U. S. Dept. Agr., Division of Chemistry, Richardson, Bul. No. 1, An investigation of the composition of American wheat and corn, 1873; Bul. No. 4, ibid., 1884; Bul. No. 9, Third report on the chemical composition and physical properties of American cereals, wheat, oats barley, and rye, 1886.

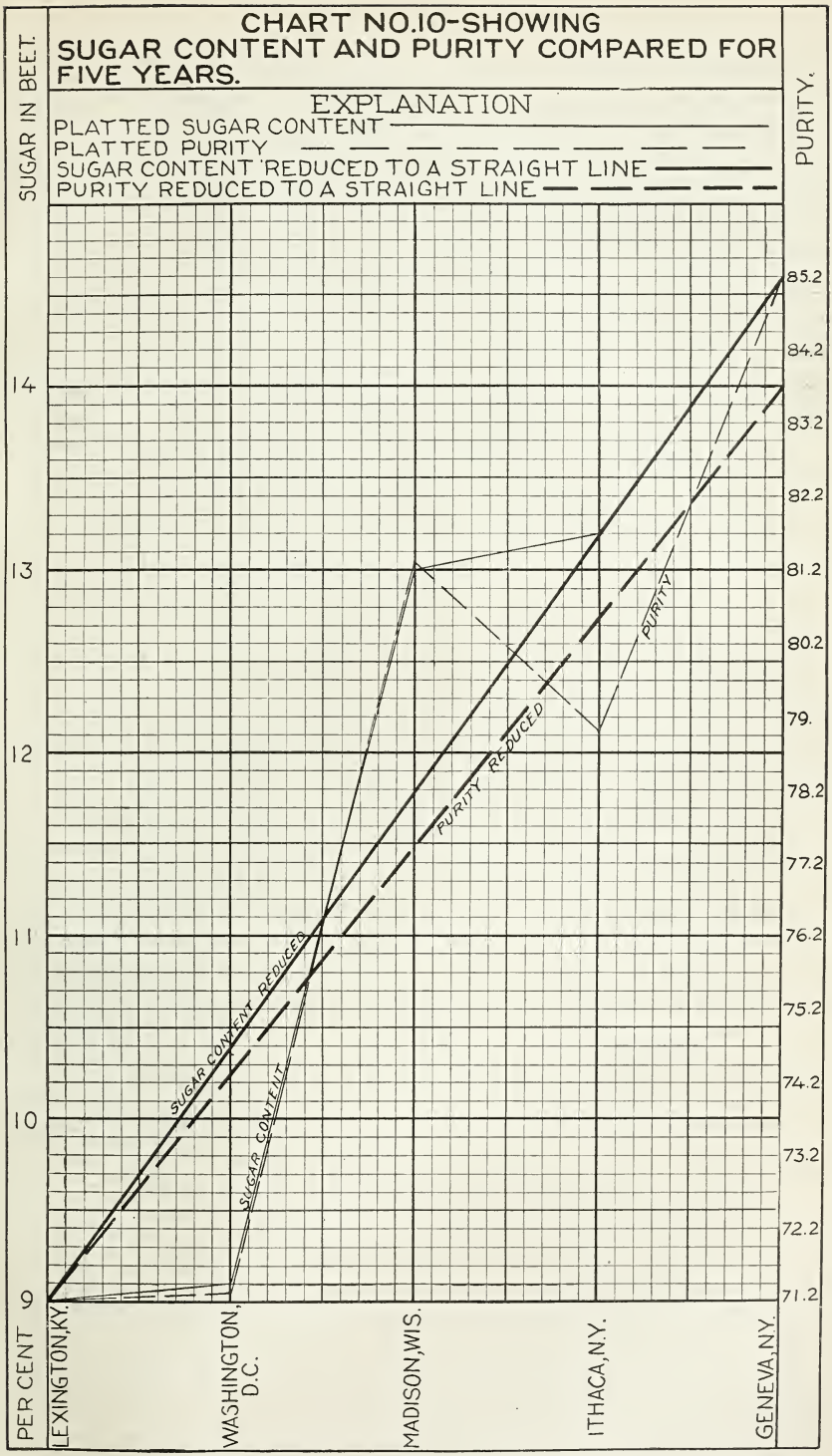

FIG. 10.—Comparison of sugar content and purity at the five stations completing the entire five years of the experiment.

was carefully studied in one or two localities without, however, extending the principle of the investigation to the extent to which it has been applied in these studies. The composition of the sorghum plant[a] also was studied throughout a series of years, but without the application of the principle of widely separated areas under the various conditions of the environment. The value of the present investigations, of course, must be judged by the data submitted, lacking as they are in many points which would lead to more definite conclusions. It appears, however, that one of the principal values of the investigation consists in marking out in a preliminary way the general principles on which such studies should be based. Larger experience and more extended investigations will serve not only to perfect the plan of operations but also to vastly increase our knowledge of the effect of environment upon the composition of plants.

[a] U. S. Dept. Agr., Division of Chemistry Bul. No. 40, Records of experiments with sorghum, 1893.

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